2018
ANNUAL REPORT

of the

INTERNATIONAL UNION OF GEOLOGICAL SCIENCES
COMMISSION ON GLOBAL GEOCHEMICAL BASELINES

January 2019

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IUGS COMMISSION ON GLOBAL GEOCHEMICAL BASELINES

URL: http://www.globalgeochemicalbaselines.eu/

1. TITLE OF CONSTITUENT BODY

IUGS Commission on Global Geochemical Baselines (CGGB).

2. OVERALL OBJECTIVES

The mission of the Commission is to:

(i) Develop a Standard Methods Manual for the Global Geochemical Reference Network project;

(ii) Establish a global Geochemical Reference Network (GRN) similar to a geodetic network for levelling existing databases (prime objective);

(iii) Prepare a global geochemical database and its representation in map form, and

(iv) 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 applied 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, and
- ✓ 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-sample media and 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 (http://iugs.org/index.php?page=resourcing-the-future-initiative), and
- Work of the newly established UNESCO International Centre on Global-Scale Geochemistry (http://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 is continuously under review and when deemed necessary is revised, as additional countries with active geochemical mapping programmes or an interest in establishing such programmes become members.

4.1. STEERING COMMITTEE

Co-Chairs: *1st Co-chair*: David B. Smith, US Geological Survey
2nd Co-chair: Xueqiu Wang, UNESCO International Centre on Global-Scale Geochemistry
Scientific Secretary: Patrice de Caritat, Geoscience Australia
Treasurer: Alecos Demetriades, Hellas

As the two Co-chairs, Scientific Secretary and Treasurer will be standing down at the end of the current four-year term, the following interim structure of the Steering Committee is proposed, and to be in effect as from March 2019. The reason for the interim structure is to accomplish a smooth transition to the permanent structure that will be proposed to the IUGS Executive Committee at the end of 2019 for approval and ratification by the IUGS Council at its March 2020 meeting in Delhi on the occasion of the 36th IGC:

Chairperson: David B. Smith
Assistant Chairperson: Kate Knights
Deputy Chairperson: Xueqiu Wang
Assistant Deputy Chairperson: Gloria Simubali
Scientific Secretary: Patrice de Caritat
Assistant Scientific Secretary: to be named
Treasurer: Alecos Demetriades
Assistant Treasurer: Christina Stouraiti
Public Relations & Finance: Ariadne Argyraki

4.2. SAMPLING COMMITTEE

Chair: Alecos Demetriades, Hellas
Supervises the development and coordination of sampling protocols in the various climatic and geomorphological provinces throughout the world.

4.3. 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.

4.4. 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: Ariadne Argyraki, 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.

4.6. REGIONAL REPRESENTATIVES

4.6.1. Africa

Theophilus C. Davies, Department of Geology, University of Nigeria, Nsukka, Nigeria
Marthinus Cloete, Council for Geoscience, Pretoria, South Africa
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

4.6.2. America - North

David Smith, United States Geological Survey, Denver, USA
Enrique Espinosa, SGM, Pachuca, Mexico
Andy Rencz, Ottawa, Ontario, Canada

4.6.3. America - South

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

4.6.4. Australasia

Patrice de Caritat, Geoscience Australia, Canberra

4.6.5. China

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

4.6.6. Europe

Clemens Reimann, Geological Survey of Norway, Trondheim, Norway
Philippe Négrel, Bureau de Recherches Géologiques et Minières, France
Anna Ladenberger, Geological Survey of Sweden

4.6.7. 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

4.6.8. Japan

Atsuyuki Ohta, Geological Survey of Japan, AIST, Tsukuba

5. INTERACTION WITH OTHER INTERNATIONAL ORGANISATIONS

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 Commission was an active participant in preparing the successful proposal originally submitted to UNESCO in 2009.

One of the most important tasks for the Commission was 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. This relationship is specified in the recently approved Statutes of the Centre (16 October 2018), *i.e.*,

Article 7: *The functions of the Centre shall be to:*

> *7.1. Apply the standardised global-scale geochemical methods developed by the IUGS Commission on Global Geochemical Baselines, so as to document the concentration and spatial distribution of chemical elements in the various environmental compartments of the Earth's surface, and to establish global geochemical baselines for monitoring future geochemical changes;*
>
> *7.2. Foster the implementation of global geochemical baseline programmes by securing funds, managing and coordinating these activities according to the scientific guidelines, determined by an External Advisory Committee cooperating with the IUGS Commission on Global Geochemical Baselines.*

Although it was expected that the collaboration between the Centre and the Commission was going to be smooth as its Steering Committee members are also members of the Centre's Governing Board and Scientific Committee, and the Centre's Executive Director is the 2nd Co-chair of the Commission, this expectation was finally proved to be deceptive. There is no close collaboration between the Centre and the Commission, just a concise report about the Centre's activities is sent at the end of each year by the Centre's Executive Director to be included in the Commission's annual report. It is hoped that this situation will change, however, in the coming months, following the clear relationship between the Centre and the Commission that is now expressed in the Centre's approved Statutes (see Article 7 above).

5.2. INTERFACE WITH OTHER INTERNATIONAL ORGANISATIONS

The Global Geochemical Baselines (GGB) project is closely associated with the work of the EuroGeoSurveys (EGS) Geochemistry Expert Group (GEG; previously the Forum of European Geological Surveys, FOREGS Geochemistry Expert Group). The GGB 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 Strategy Documents, 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 at the continental, regional and local scales.

In 2014, 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 and finalised the cooperation. The cooperation agreement, because of the two continental-scale projects, FOREGS and GEMAS, included collaboration in continental-scale soil geochemistry in Europe.

In 2014, the Commission 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 three two-day workshops on *"Global Geochemical Baselines"* during (i) the 3rd YES Congress in Dar es Salaam, Tanzania (12-13 August 2014) with 59 attendees; (ii) 4th YES Congress in Tehran, Iran (29-30 August 2017), with 48 attendees, and (iii) RFG2018 in Vancouver, Canada (18 & 22 June 2018) as detailed in Section 6.3. This collaboration is continuing with the organisation of a workshop on the occasion of the 5th YES Congress in Berlin, Germany (September 2019) as detailed in Section 10. There is also an on-going discussion about the establishment of a YES Working Group on Applied Geochemistry, which is expected to be realised in 2019.

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 the 14th August 2014 in Dar es Salaam (Tanzania), and the final version was presented at the OAGS Director's meeting in Gaborone (Botswana), 13-16 October 2014. The three-year joint project (2016-2019) covers 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, and recently at the 11th OAGS Annual General Meeting (8-10 November 2018) in Dakar, Senegal, where a collaboration MoU was signed between EGS and OAGS.

The Commission 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) in collaboration with the EGS Geochemistry Expert Group, the Geological Society of Africa and the Organisation of African

Geological Surveys. In August 2017, it became obvious that the GEO Group on Earth Observations is not a funding platform, and the funding should be sought from other sources. Hence, the AfriGEOSS proposal was recently discussed with the EGS Secretary General, and Philippe Négrel, the new Chairperson of the EGS Geochemistry Expert Group will be discussing with the PanAfGeo coordinator the possibility of including part of the AfriGEOSS capacity building programme in the 2019 programme, and the remaining in Phase II of PanAfGeo.

EuroGeoSurveys participated 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, which was recently completed (October 2018). The results of both the FOREGS Geochemical Atlas of Europe and GEMAS (GEochemical Mapping of Agricultural and grazing land Soil of Europe) projects were used by this project.

In North America, the Commission 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 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. Further, it participated with a representative in the RFG workshop in Namibia (24-30 July 2015), and in the writing of the report "*Resourcing Future Generations – A Global Effort to Meet the World's Future Needs Head-on*", and subsequently a paper published in Nature in March 2017 with the title "*Mineral supply for sustainable development requires resource governance*". In 2018, on the occasion of RFG2018 in Vancouver the Commission organised a session on *"Global-Scale Geochemical Mapping: A Critical Component for Resourcing Future Generations"* (see Section 6.3.3), and a two-day workshop '*Exploration Geochemistry: From fundamentals to the field*' in collaboration with the Association of Applied Geochemists (see Section 6.3.1).

6. ACTIVITIES IN 2018

6.1. IUGS EXECUTIVE COMMITTEE MEETING

The 72nd IUGS Executive Committee meeting was hosted by the GFZ German Research Centre for Geosciences (Potsdam, Germany) from the 22nd to the 26th of January 2018; the open session was on the 22nd and 23rd of January 2018. The Treasurer reported the Commission's 2017 activities, and the 2018 programme, as well budget requirements. Among the comments and recommendations made by Executive Committee members were:

- The Commission to use the surplus amount accumulated gradually over the years to finance most of its 2018 activities;
- The Annual Report to be restructured with its main body reporting the Commission's activities, and other material to be placed in appendices (*this annual report follows the recommendation*), and
- To put in place standards for establishing baselines that can be employed by the broad Earth Science community, as per the IUGS definition of Commissions (a well-illustrated Manual of Standard Methods for the Global Geochemical Baselines project, and not only, was started – see Section 6.4).

6.2. ANNUAL BUSINESS MEETING

The joint annual business meeting of the EuroGeoSurveys Geochemistry Expert Group and IUGS Commission on Global Geochemical Baselines was hosted by the Instituto Geologico y Minero de España (IGME) at its premises in Madrid from the 16th to the 19th May 2018 (see Appendix 1). In total, 29 people attended the meeting from Armenia, Australia, Chile and European countries (see Table 1) (Fig. 1). The first two days were devoted to the business meeting and the third to an excursion to an exploration-mining area for copper (Otero de Herreros). On the fourth day an attempt was made to video tape the global geochemical baselines sampling techniques.

Table 1. List of participants of joint annual meeting.

Participants of Annual Business Meeting	
1. Clemens Reimann, (Chair, Norway) 2. Philippe Négrel (Deputy Chair, France) 3. Anna Ladenberger (Deputy Chair, Sweden) 4. Gerhard Hobiger (Austria) 5. Sophie Decree (Belgium) 6. Timo Tarvainen (Finland) 7. Manfred Birke (Germany) 8. Maria Kaminari (Hellas) 9. Daniella Tolmács (Hungary) 10. Gyozo Jordan (Hungary) 11. Pat O'Connor (Ireland) 12. Stefano Albanese (Italy) 13. Belinda Flem (Norway) 14. Maria Joao Batista (Portugal) 15. Aleksandra Gulan (Serbia) 16. Mateja Gosar (Slovenia)	17. Alejandro Bel-lan (Spain) 18. Juan Locutura (Spain) 19. Paula Adanez (Spain) 20. Javier Sanchez Espana (Spain) 21. Juan Martin Mendez (Spain) 22. George Morris (Sweden) 23. Jasper Griffioen (The Netherlands) 24. Fiona Fordyce (United Kingdom) 25. Gevorg Tepanosyan (National Academy of Science Armenia) 26. Martin Soriano (Australia) 27. Catalina Ramirez Mora (Chile) 28. Alecos Demetriades (IUGS Commission on Global Geochemical Baselines, Hellas) 29. Ariadne Argyraki (IUGS Commission Global Geochemical Baseline, Hellas)

Figure 1. Group photograph of meeting participants (Photo by Gerhard Hobiger).

6.3. RFG2018 CONFERENCE WORKSHOP AND SESSION

The YES Network submitted a request to the organisers of RFG2018 Conference for the Commission to organise a two-day workshop for its members. Following discussion with the

RFG2018 organisers, it was proposed to collaborate with the Association of Applied Geochemists (AAG), because there was already a workshop with Peter A. Winterburn (University of British Columbia) as convenor, with the title: *Exploration Geochemistry – From fundamentals to the field*. The Commission collaborated with P.A. Winterburn, and a two-day workshop was organised. The first day (17 June 2018) was devoted to lectures, and the second day (22 June 2018) to a field-training course (see Appendix 2).

6.3.1. Workshop: Exploration Geochemistry - From fundamentals to the field

The outline of the workshop was:

> *Geochemistry remains one of the fundamental tools used in mineral exploration along with geology and geophysics, however, underlying fundamentals that govern the behaviour of chemical elements in the environment is often poorly understood by geologists leading to inappropriate application. Modern analytical techniques often provide a wealth of trace element information for 50 plus elements at sub ppm level, however, few organisations maximise the value of this information in the context of target selection, prioritisation and geochemical-geological mapping. This short course is intended to introduce the geologist / geochemist to simple fundamental concepts that govern the distribution and dispersion of chemical elements in mineral deposits and the natural environment and apply the principles to the design of surveys, analytical methodology/technology, target selection/prioritisation and lessons to be learnt from survey post-mortems.*

The eleven course lectures were:

1. *Exploration Geochemistry – From fundamentals to the field: course outline* by P.A. Winterburn
2. *Introduction* by P.A. Winterburn
3. *Geochemistry of select mineralisation styles* by P.A. Winterburn
4. *Weathering of mineral deposits* by P.A. Winterburn
5. *Survey design and sample media* by P.A. Winterburn
6. *Drainage surveys* by John Gravel (JG Consulting)
7. *QA/QC – Field to lab* by Jamil Sader (Bureau Veritas Minerals)
8. *The Central African Copperbelt* by P.A. Winterburn
9. *Strategic minerals* by P.A. Winterburn
10. *Sampling techniques used in Global Geochemical Baseline Mapping* by Alecos Demetriades (Chair of Sampling Committee, IUGS CGGB)
11. *Interpretation of data from continental-scale geochemical mapping projects* by David B. Smith (1st Co-leader, IUGS CGGB)

The lecture course was attended by 25 people (Fig. 2), four of which were YES Network members, who did not pay the Workshop fee.

6.3.2. Field-training workshop

To organise the field-training course a local person was needed. Peter A. Winterburn suggested John Gravel (local applied geochemist), whose assistance was greatly appreciated in the organisation of the field-training course. Alecos Demetriades (Chair of Sampling Committee) communicated with John, and sent him details about the field sampling techniques used in the Global Geochemical Baselines project. John proposed to begin with the Britannia Creek catchment basin, where the Britannia Creek Cu mine, with Pb-Zn-Au-Ag-Cd, was in operation from 1904 to 1974, and today has been converted into the Britannia Mine Museum, and even went for a day before the conference to check the field conditions. On Tuesday, 19th June 2018,

Britannia Creek was visited by Alecos Demetriades, Patrice de Caritat (Commission's Scientific Secretary) and John Gravel in order to check the conditions, and prepare the demonstration sampling sites.

Figure 2. Participants in the Exploration Geochemistry short course (Photo by John Gravel).

Britannia Creek is a small catchment basin with a comparatively high energy stream in its upper reaches (rapids), and because of the mountainous relief the stream has high energy even at its lower reaches as indicated by the large boulders in its bed and bank loads, and it has not developed an alluvial floodplain with fine-grained sediments. In any case, this is a small catchment basin that will not be selected for sampling in the global geochemical baselines project. However, it can be used for demonstration of a number of sampling techniques, such as stream sediment, stream water, heavy mineral concentrates, and moss mat sediment. John suggested that we go further north to Squamish River, which is a larger river with braids, ox-box channel and has a well-developed alluvial floodplain. We did a traverse along the southern bank of the river and found very good exposed sections of floodplain sediment with many layers. However, these were at some distance from the main road, and in the group, there was a person with mobility problems. Hence, a site near to the track road was selected for the demonstration of floodplain sediment sampling.

The field-training course was unique, because there were 6 tutors: Peter A. Winterburn, John Gravel, Ray Lett, Colin Dunn, Patrice de Caritat and Alecos Demetriades. The reason for so many tutors the cancelling of the more extended field-training course due to lack of participants, and all tutors offered to join the YES Network one-day field-training course with 16 participants (see Appendix 2 for details).

Initially the Commission planned to sponsor the field-training workshop. However, due to the reduced annual funding from IUGS this was not possible. The financial problem was discussed with the YES Network President, Meng Wang, who offered to sponsor the field-training course. The costs included the hiring of the coach, packed lunches, purchase of spade, Britannia Mine Museum entry tickets, *etc.*, which totalled US $1469.99.

Figure 3. Participants in the field-training course, Britannia Creek, Vancouver, RFG2018 (Photo by Meng Wang).

6.3.3. Session on Global Geochemistry Baselines

The Commission is actively involved in the IUGS initiative "*Resourcing Future Generations*" (http://www.rfg2018.org/) and has organised on Monday, 18th June 2018, a dedicated session in the RFG2018 conference with the title: *Global-scale geochemical mapping: A critical component for resourcing future generations*. This session was included in the theme '*Resources and Society*'. The following was the session summary text:

> *An accessible, global-scale geochemical database, generated using standardised sampling, analytical, and quality control protocols, is a critical requirement as nations strive to meet the needs of future generations for adequate mineral resources exploited in an environmentally responsible manner. Such a database provides not only important data for exploration, but also vital information on the background variation of potentially toxic elements that might be released to the environment during mining and mineral processing. This session will focus on the status of developing such a global geochemical database and provide case histories of global-scale geochemical studies.*

The twelve PowerPoint presentations were:

- *Global-scale geochemical data in the exploration and development of mineral resources for future generations* by David B. Smith, Alecos Demetriades, Patrice de Caritat and Xueqiu Wang (presented by D.B. Smith)
- *Mapping the Chemical Earth: multi-scale geochemical data for resourcing future generations* by Wang Xueqiu
- *Geochemical mapping of Europe for the delineation of metallogenic provinces, and establishment of baseline for environmental management* by Alecos Demetriades, Timo Tarvainen, Clemens Reimann, Manfred Birke, Philippe Négrel and Anna Ladenberger (presented by A. Demetriades)
- *Low-density geochemical mapping at continental-scale reveals background for emerging tech-critical elements* by Philippe Négrel, Anna Ladenberger, Clemens Reimann, Manfred Birke, Alecos Demetriades, Martiya Sadeghi and the GEMAS Project Team (presented by P. Négrel)
- *The geochemical atlas of Italian agricultural and grazing land soils* by Domenico Cicchella, Stefano Albanese, Annamaria Lima, Enrico Dinelli, Paolo Valera, D. Zuzolo, Attila Petrik and Benedetto De Vivo (presented by B. De Vivo)
- *Continental-scale mineral prospectivity assessment using the National Geochemical Survey of Australia (NGSA) dataset* by Patrice de Caritat, M.J. Cracknell, Eric Grunsky, P. Main and Alan Mann (presented by P. de Caritat)
- *Arsenic distribution in soils of the conterminous United States: Results from continental-scale geochemical mapping* by David B. Smith
- *Regional geochemical mapping in Ontario: A one-time, multi-use, wide spectrum characterization of ambient groundwater chemistry* by Stewart Hamilton
- *Relationship between fluoride content distribution characteristics and endemic fluorosis in China* by Qingqing Liu
- *Improving the efficiency of regional geochemical studies on the basis of innovative technologies of metallogenic prognosis and interpretation of geochemical data* by Igor G. Spiridonov

This session was jointly organised by the IUGS Commission on Global Geochemical Baselines (IUGS CGGB was a Technical Partner for RFG2018), the UNESCO International Centre on Global-Scale Geochemistry, and the Association of Applied Geochemists (AAG was a Technical Partner for RFG2018). The session attendees varied from 17 to 52.

6.4. MANUAL OF STANDARD METHODS FOR ESTABLISHING THE GLOBAL GRN

Directly after the IUGS Executive Council meeting in January 2018 the work on a comprehensive '***International Union of Geological Sciences Manual of Standard Methods for Establishing the Global Geochemical Reference Network***' has started. The FOREGS Field Geochemical Mapping Field Manual (Salminen, Tarvainen *et al.*, 1998) is used as basis, because it was the first multinational project to be carried out in 26 European countries according to the specifications of IGCP 259 (Darnley *et al.*, 1995). The present manual will be far more extensive and well-illustrated. Below an outline of its structure is given. It is anticipated that this will be a unique manual of methods used in applied geochemistry, because the authors of each chapter have considerable experience in geochemical methods from sampling, sample preparation, laboratory techniques, quality control, data management and data processing. It is anticipated that it will be completed in the first half of 2019.

Editors: Alecos Demetriades, David B. Smith, Patrice de Caritat, Kate Knights, Ariadne Argyraki, Gloria Simubali, Christina Stouraiti (Note: Dr. Xueqiu Wang will be asked too)[1]

Abstract
Preface
Abbreviations

Chapter 1: INTRODUCTION (Reijo Salminen, Timo Tarvainen, Alecos Demetriades, Miloslav Ďuriš, Fiona M. Fordyce, Virgilija Gregorauskiene, Juan Locutura, Clemens Reimann, Otmar Schermann, Agnette Steenfelt ,,,,,,) – It will be based on the FOREGS Geochemical Mapping Field Manual, but expanded)

Chapter 2. GLOBAL TERRESTRIAL NETWORK GRID CELLS AND SELECTION OF SAMPLE SITES (Alecos Demetriades, Timo Tarvainen, Robert G. Garrett, Reijo Salminen, *et al.*)

Chapter 3. SAMPLING

3.1. Samples to be collected from the <100 km^2 catchment basin (2nd order streams):

- ***3.1.1. Stream sediment*** (Alecos Demetriades, Fiona Fordyce, Christopher C. Johnson, Reijo Salminen, Mikael Eklund, Juan Locutura, *et al.*)
- ***3.1.2. Stream water*** (Timo Tarvainen, Tarja Hatakka, Mikael Eklund, Reijo Salminen, Alecos Demetriades, *et al.*)
- ***3.1.3. Overbank sediment*** (top and bottom) (Alecos Demetriades, Rolf Tore Ottesen, Jim Bogen, Juan Locutura, Ignace Salpeteur, Alejandro Bel-Ian, Walter De Vos (Dr. Xueqiu Wang will be asked)[2])
- ***3.1.4. Residual soil*** (top and bottom) (Alecos Demetriades, Maria Joao Batista, David Smith, Edith Haslinger, Virgilija Gregorauskiene, Zomenia Zomeni *et al.*)
- ***3.1.5. Rock*** (this is a sampling medium that is not included in the FOREGS field manual, and it should be included).

3.2. Samples to be collected from the 1000 to 6000 km^2 catchment basin (3rd order streams)

- ***3.2.1. Floodplain sediment*** (top and bottom) (Alecos Demetriades, Rolf Tore Ottesen, Jim Bogen, Juan Locutura, Ignace Salpeteur, Alejandro Bel-Ian, Walter De Vos (Dr. Xueqiu Wang will be asked)[3])

Note: As the only difference between overbank and floodplain sediment is the stream order, the instructions are exactly the same.
Then Chapters on:

- **Chapter 4: Special terrains**

  4.1. Karst (Alecos Demetriades, Simon Pirc, Milan Bidovec and France Šušteršič)

  4.2. Desert (Xueqiu Wang, ……

[1] Since September 2018, Dr. Xueqiu Wang has not replied to repeated invitations to join the Editorial team.
[2] As footnote 1 above.
[3] As footnote 1 above.

4.3. Semi-desert grassland (Xueqiu Wang, …..

4.4. Arctic (for discussion with Agnette Steenfelt, Jim Bogen)

- **Chapter 5: SAMPLE PREPARATION** (Alecos Demetriades, Manfred Birke, Christopher C. Johnson *et al.)*
- **Chapter 6: PREPARATION OF REFERENCE MATERIALS FOR EXTERNAL QUALITY CONTROL** (Pavol Lučivjanský and Daniela Mackových)
- **Chapter 7: ANALYTICAL METHODS** (Gwendy Hall and Manfred Birke)
- **Chapter 8: QUALITY CONTROL AND ESTIMATION OF MEASUREMENT UNCERTAINTY** (Alecos Demetriades and Ariadne Argyraki)
- **Chapter 9: DATA CONDITIONING** (Christopher C. Johnson and Bob Lister)
- **Chapter 10: CRITERIA OF GLOBAL GEOCHEMICAL BASELINES DATABASE** (Timo Tarvainen, Igor Bogatyrev, Steven M. Smith, Robert G. Garrett, Eric C. Grunsky, Nils Gustavsson, *et al.*)
- **Chapter 11: DATA PROCESSING AND PRESENTATION** (Timo Tarvainen, …)

REFERENCES

Appendix 1: World soil profiles (Edith Haslinger, …..)
Appendix 2: Quality control script (Evripides Vassiliades)
Appendix 3: Five-random sample site generation script in 160x160 km grid cells (Geng Xiaoyuan and Juanxia He)
Appendix 4: Eight-random sample site generation script in 160x160 km grid cells (Geng Xiaoyuan and Juanxia He)
Appendix 5: Sixteen-random sample site generation script – one in each 40x40 km grid cell (Geng Xiaoyuan and Juanxia He)
Appendix 6: Generation of random sample numbers for randomisation of samples
Appendix 7: Taking good photographs for sample site documentation
Appendix 8: Field observation sheets

6.5. PARTICIPATION IN THE SECOND MEETING OF UNESCO ICGG

The Commission participated in the biennial meeting of the UNESCO International Centre on Global-Scale Geochemistry (15-17 October 2018) with its representative in the Governing Board and Scientific Committee, *i.e.*, Commission's Treasurer (Fig. 4). The Commission's contribution was in the restructuring of the Centre's three set of statutes, namely Centre's, Governing Board's and Scientific Committee's, into a single document, and the organisation of the Secretariat office.

(a) (b)

Figure 4. Group photograph of the UNESCO ICGG (a) Governing Board and (b) Scientific Committee meetings, Langfang, China.

On Monday afternoon, 15th October 2018, the basic work of reviewing the combined Centre's Statutes was done by a small team, and in the evening the Commission's representative undertaken to check and edit the Centre's Statutes. On Tuesday, 16th October 2018, the Commission's representative projected on-screen the Statutes, and each article was read and approved by the Governing Board members. The Governing Board members subsequently signed three hard copies of the Centre's Statutes. Hence, the Centre has now the approved Statutes that are necessary for its operation.

The Scientific Committee's meeting was not so smooth as that of the Governing Board. The main problem was the Centre's Executive Director, Dr. Xueqiu Wang, who insisted to use the Chinese floodplain sediment sampling technique in the Global Geochemical Baselines project, and not the accepted method used in the establishment of the European Global Geochemical Reference Network, *i.e.*, FOREGS Geochemical Mapping Field Manual (Salminen, Tarvainen *et al.*, 1997). The Chinese floodplain sediment sampling method has already been criticised in the Commission's 2017 annual report on pages 37 to 39 and 40 to 42, and more recently in a paper published in a Special issue of Geochimica Brasiliensis:

Demetriades, A., Smith, D.B., Wang, X., 2018. *General concepts of geochemical mapping at global, regional, and local scales for mineral exploration and environmental purposes*. In: Licht, O.A.B. (Guest Editor), Geochemical Mapping. Special Issue, Geochimica Brasiliensis, 32(2), 136-179; http://doi.org/10.21715/GB2358-2812.2018322136.

The peculiarity of the aforementioned paper is that the Centre's Executive Director, Prof. Xueqiu Wang, is co-author, which means that he accepts the contents of the paper, including the described sampling procedures and the critical comments in Section 10 '*Pitfalls and procedures to avoid*' (p.165-170).

6.5.1. Comments on the Chinese floodplain sediment sampling method

The first version of the Chapter on overbank and floodplain sediment sampling of the well-illustrated '*International Union of Geological Sciences Manual of Standard Methods for Establishing the Global Geochemical Reference Network*', which is in the process of writing (see Section 6.4), was circulated in order to be used by the Centre. It is stressed that the sampling method of overbank and floodplain sediment was well-researched from 1989 to 1992 by the Regional Geochemistry Working Group of the Western European Geological Surveys (forerunner of the Geochemistry Expert Group of EuroGeoSurveys), and the description of the sampling method, included in the FOREGS Geochemical Mapping Field Manual, is based on this research. The UNESCO International Centre on Global-Scale Geochemistry is obliged to follow (a) the protocol used in the FOREGS project in order to ensure consistent, reliable and comparable results, and (b) according to the Centre's Statutes (see Section 5.1, Article 7, Paragraph 7.1).

The Chinese floodplain sediment sampling method was circulated too, and it is a poor translation in English of the 2009 protocol used in the China Geochemical Baselines project, and named in 2018 as the '*Protocol for Global Geochemical Baselines*'. In this project, composite top and bottom alluvial soil samples were collected from agricultural fields, *i.e.*, top samples are generally collected from the A soil horizon at a depth of 0-25 cm or from the surface to the bottom of the A horizon if the thickness of the A-horizon is <25 cm, and the bottom samples are collected from a depth of 100 to 150 cm with an auger and, thus, there is no control if the same layer is sampled.

What was actually sampled in the China Geochemical Baselines project is the Ap ploughed horizon (similar to the European GEMAS[4] project), as the sample sites are located in agricultural land, and undoubtedly the top sample is affected by the agricultural activities. Such locations are avoided in the Global Geochemical Baselines project, where the top floodplain sediment samples are collected from natural and undisturbed sites. It is stressed that the objective of the Global Geochemical Baselines project is to map the geochemistry upstream from the sampling site, and this includes the mapping of regional contamination patterns. Therefore, the condition is that sampling sites must be selected at locations unaffected by human activities or at worse the sites should be least affected by anthropogenic contamination, and special precautions should be adopted to avoid local contamination, such as agricultural in this case (Darnley *et al.*, 1995).

The Chinese bottom floodplain samples are depth-based, and not layer-based, without any consideration that from 100 to 150 cm more than one layer may be sampled.

In conclusion, the Chinese floodplain sediment sampling method does not follow the established methodology used in the first multinational project carried out in 26 European countries, known as the FOREGS Geochemical Atlas of Europe (Salminen, Tarvainen *et al.*, 1998; Salminen *et al.*, 2005; De Vos, Tarvainen *et al.*, 2006), and does not meet the standards set by the IGCP 259 report by Darnley *et al.* (1995).

The Chinese floodplain sediment sampling method was the subject of an exhaustive E-mail discussion before the biennial Centre's meeting, and the recommendation was to accept the well-written and illustrated Chapter that will be included in the '*International Union of Geological Sciences Manual of Standard Methods for Establishing the Global Geochemical Reference Network*'. As the Chair of the Commission's Sampling Committee already strongly criticised the Chinese protocol in the Commission's 2017 annual report, and more recently in a paper published in a Special Issue of Geochimica Brasiliensis (see Section 6.5), is worth including the E-mail comments of the Commission's 1st Co-chair, David B. Smith:

"*It is unfortunate that this document was not submitted to the Scientific Committee in 2016 for a thorough review. There are several issues that could have been resolved before the Centre began discussions with countries regarding their participation in the project. My review focuses primarily on the sampling protocols developed by the UNESCO Centre for Global-Scale Geochemistry for the Global Geochemical Baselines Project. From my point of view, the biggest issue concerns the recommended sample medium for the global baselines project. This sampling medium is usually referred to in the UNESCO Centre's protocols as "fluvial soils formed from catchment sediment", or "soils formed by overbank and floodplain sediments". The sampling protocols are confusing. In some parts of the text (e.g., General Guidelines), the two samples to be collected at each site are said to be "soil A horizon at a depth of 0-25 cm" and "deep samples are from a depth of more than 100 cm." In other parts of the text (e.g., section 4.2), the two samples are described as "top samples are collected from 0-25 cm, and deep samples under a depth of 100 cm." The first description states the top sample should be collected on the basis of soil horizons, whereas the second description states that the shallow sample is based only on depth. I would also point out that, from the description and the photographs, it appears that many sample sites are located on agricultural land. If the sampling sites are supposed to avoid human effects, then agricultural sites are not appropriate because of possible application of pesticides and fertilizers.*

Alecos Demetriades has had the opportunity to observe the application of these protocols in the field during his visits to China. He has pointed out that individual layers of floodplain/overbank sediment are being mistakenly identified as genetic soil horizons. I think it is critical to clarify if the sampling crews are to sample genetic soil horizons (e.g., the soil A

[4] Reimann, C., Birke, M., Demetriades, A., Filzmoser, P. & O'Connor, P. (Editors), 2014. *Chemistry of Europe's agricultural soils – Part A: Methodology and interpretation of the GEMAS data set*. Geologisches Jahrbuch (Reihe B 102), Schweizerbarth, Hannover, 528 pp., http://www.schweizerbart.de/publications/detail/isbn/9783510968466.

horizon) in which the original floodplain sediment layers have been to some extent altered in color, texture, structure, etc. by soil-forming processes or if the crews are to sample individual sediment layers, deposited during different flood events, that still retain their original color, texture, structure, etc. As currently written, the UNESCO Centre's protocols are confusing, at best. I assume this is mostly due to translating from Chinese to English, but the protocols need to be stated much more clearly. That is why the protocols should have been submitted for review much earlier. If the English-language protocols, as translated from the Chinese, are confusing to native English speakers, imagine how a native Spanish or Arabic speaker must feel in trying to interpret the protocols.

I strongly believe it is necessary that the UNESCO Centre's current protocols be replaced by the protocols for overbank/floodplain sediments being developed by the IUGS Commission on Global Geochemical Baselines. These protocols are being developed by applied geochemists with many years of experience in working with these types of sample media. These protocols, the current draft of which has been distributed to the Scientific Committee by Alecos Demetriades, are clearly written and, I believe, accurately reflect the sampling methods that the authors of the UNESCO Centre's protocols intended for overbank/floodplain sediments. The language issue in going from Chinese to English is always going to be a difficult one and, in my opinion, is the primary source of the current problems being discussed. The sampling protocols being developed by the IUGS Commission represent an improved version while maintaining the objectives set out in the UNESCO Centre's protocols. In my opinion, there should be little difficulty in transitioning from the current UNESCO Centre's protocols to the IUGS Commission's protocols. I hope the leadership of the UNESCO Centre and the members of the Scientific Committee will agree with this simple solution to the sample issues under discussion.

One thing that is lacking in the UNESCO Centre's protocols that will be a major part of the IUGS Commission's Manual of Standard Methods is a section that explains, in detail, the survey design. In this section of the IUGS Manual, the authors: (1) Clearly state the objectives of the global-scale project with regard to overbank/floodplain sediment, as well as for the other sampling media (stream sediment, stream water, soil, and rock). (2) Detail the philosophy of sample site selection (e.g., What is a site — is it a point or an area)? The Commission's manual recommends that the selected sampling sites avoid, as much as possible, human influence; this implies that agricultural fields should be avoided. (3) Provide a clear statement of the target sampling population for the project (e.g., all overbank/floodplain sediments not obviously affected by human activity; this would exclude agricultural land). The IUGS Commission's sampling manual will provide a detailed design statement that will eliminate problems in the future as questions arise about how the sites were selected."

Unfortunately, Dr. Xueqiu Wang (Centre's Executive Director) is not accepting logical recommendations, and still insists for the Centre to develop its own protocol, although he agreed in principle to follow the Commission's floodplain sediment sampling scheme, as the Centre, according to article 7.1 of its Statutes, is obliged to "***Apply the standardised global-scale geochemical methods developed by the IUGS Commission on Global Geochemical Baselines***" (see Section 5.1).

Recommendation: The IUGS Executive Committee should send a letter to the Director of the Centre stressing that:

(i) The standardised global-scale geochemical methods that are being developed by the IUGS Commission on Global Geochemical Baselines must be followed, according to Paragraph 7.1 of Article 7 of its Statutes (see Section 5.1);

(ii) The Centre's Executive Director must collaborate with the Commission, and

(iii) The 'International Union of Geological Sciences Manual of Standard Methods for Establishing the Global Geochemical Reference Network' must be used by the Centre for the Global Geochemical Baselines project, *and no other manual*.

6.5.2. Comments on the Agreements signed with other countries

The Agreements signed between China Geological Survey and other countries since 2014 were made available before the 2nd meeting of the Governing Board and Scientific Committee of the UNESCO International Centre on Global-Scale Geochemistry. The sections concerning the Global Geochemical Baselines project were abstracted without any editing or correction of the English language and are tabulated in Table 2. The countries that signed agreements before the operation of the International Centre are Mexico (2014) and Iran (2015), and after May 2016 are Cambodia (2016), Russian Federation (2016), Ethiopia (2016), Nigeria (2017) and Argentina (2017). Agreements were signed with Morocco and Turkey, but these do not include work for the Global Geochemical Baselines project.

The first comment is that these agreements were not signed with the other countries by the UNESCO International Centre on Global-Scale Geochemistry but by China Geological Survey.

Table 2. Summary of the agreement conditions for the Global Geochemical Baselines signed between China Geological Survey and Argentina, Nigeria, Ethiopia, Russian Federation, Cambodia, Iran and Mexico.

Country	Agreement Conditions	Comments
Argentina (Agreement signed on the 24th of September 2017)	**Article 2: Purpose and Contents of the Cooperation** Section 2.2. Project Area: *The global-scale will cover the whole land of national*, the National-scale Geochemical Mapping project will cover the potential areas for mineral resources and black soil areas according to interests of the both parties. Section 2.3. Cooperation Contents *Paragraph 2.3.2. Global-Scale Geochemical Baseline: It will be implemented across the whole territory of Argentina, based on the Global Reference Networks (www.globalgeochemicalbaselines.eu). Catchment sediment (Floodplain/overbank sediment/alluvial soil) samples will be collected at 1 location per 80kmx80km grid. Top sample from 0-25 cm and deep sample under a depth of 100 cm will be collected at each location. The total samples will be delivered to China for analysis of 76 elements in China Labs. The duplicates of these samples will remain in Argentina.* **Article 3: Project Duration and Schedule** Section 3.1. Duration of Cooperation Project: The duration of this cooperation project is 4 years, from 2018 to 2021.	Sample medium: Knowing that the Chinese geochemists prefer to collect overbank sediment from 3rd order streams, and alluvial soil from agricultural areas, it can be stated that this approach does not meet the requirements of the Global Geochemical Baselines (GGB) project, which requires that overbank sediment samples are collected from 2nd order streams, and that sites with known local contamination, such agricultural land, should be avoided, as the condition is to map regional contamination patterns. Sampling density: The sampling density of 1 location per 80x80 km, *i.e.*, 4 samples/160x160 km, does not meet the minimum requirements of the GGB project, which requires the collection of samples from at least 5 drainage basins. Sampling: Depth related samples are collected, whereas the GGB requirement is for the collection of layer-based samples.
Nigeria (Agreement signed on the 23rd September 2017)	**Article 2: Purpose and Contents of the Cooperation** Section 2.2. Project Area: The project will cover the whole land of Nigeria, approximately 923,800 km^2. Section 2.3. Cooperation Contents *Paragraph 2.3.2. Global geochemical baseline: Global Geochemical Baselines Project will be implemented across the whole territory of Nigeria*	The comments are the same as for Argentina (see above).

Country	Agreement Conditions	Comments
	based on the Global Reference Networks (www.globalgeochemialbaselines.eu). Catchment sediment (Floodplain/overbank sediment/alluvial soil) samples will be collected at 1 location per 80kmx80km grid. Top sample from 0-25 cm and deep sample under a depth of 100 cm will be collected at each location jointly by the two parties. Samples will be prepared in Nigeria and analysed in Nigeria and China for 76 elements or more. Some of the samples will be chosen and prepared as standard reference materials for Nigerian Laboratory. **Article 3: Project Duration and Schedule** Section 3.1. Duration of Cooperation Project: The duration of this cooperation project is 5 years, from 2017 to 2021.	
Ethiopia (Agreement signed on the 12th of April 2016)	**Article 2: Purpose and Contents of the Cooperation** Section 2.1. Cooperation Purpose: The main purposes of the project include: capacity building on geochemical mapping techniques, analysis of 76 elements for Global Geochemical Baseline …. Section 2.2. Project Area: *The whole land area of Ethiopia, approximately 1,100,000km^2.* Section 2.3. Cooperation Contents *Paragraph 2.3.2. Global-Scale Geochemical Baseline: Jointly collect floodplain / overbank / stream sediment samples in the whole area of Ethiopia, at a sample density of 1/160x160 km^2 and conduct preparation of samples in the field. Train Ethiopian geochemists on field sampling and sample preparation methods. The samples collected will be shipped and analyzed for 76 elements in China labs.* Section 2.4. Duration of Cooperation Project: The duration of this cooperation project is five (5) years, which is from May, 2016 to December, 2020.	The comments are the same as for Argentina (see above) with a different comment with respect to the sampling density. In the case of Ethiopia, the sampling density is 1 sample/160x160 km, which does not meet the minimum GGB requirement of 5 samples/160x160 km.
Russian Federation (Agreement signed on the 15th of July 2016)	Section 2.1. The content of cooperation, milestones and deadlines *Paragraph 2.1.1. Stage I: 2017-2019:- The geochemical mapping should include: Geochemical sampling of global scale (1:5,000,000) in the border region of Russia and China*	No details are given about the sample type and sampling density.
Cambodia (Agreement signed on the 9th of September 2016)	Section 2.1. Cooperation Purpose *Paragraph (2): To provide global-scale geochemical baselines data and maps of 76 elements.* Section 2.3. Cooperation Contents *Paragraph 2.3.2. Global geochemical baseline: Global geochemical baselines project will be implemented across the whole territory of Cambodia based on the Global Reference Networks (www.globalgeochemicalbaselines.eu). Two catchment sediment (floodplain / overbank sediment / alluvial soil) samples will be jointly collected at a density of 1 samples / (80km x 80km) from surface and depth layers by the PARTIES. Half parts of each sample will be delivered to*	The comments are the same as for Argentina (see above).

Country	Agreement Conditions	Comments
	China for 76 element analysis. The remaining half will be kept by GDMR. The selected samples shall be used as the Cambodian reference standards for the future national or regional geochemical mapping. **Article 3 – Project Duration and Schedule** Section 3.1. Duration of Cooperative Project: The duration of this cooperative project is 4 years, from 2016 to 2019.	
Iran (Agreement signed on the 22nd October 2015)	**Article 2 - Purpose and Contents of the Cooperation** Section 1. Cooperation Purpose: The main purposes of the PROJECT are (Paragraph 2): to provide global-scale geochemical baselines data and maps of 76 elements. Section 2: Project Area: The Global Geochemical Baselines project will cover the whole land of Iran, approximately 1,648,000 km^2. Section 3: Cooperation Contents *Paragraph 2: Global geochemical baseline: Global Geochemical Baselines will be implemented across the whole territory of Iran based on the Global Reference Networks (www.globalgeochemicalbaselines.eu). Catchment sediment (Floodplain/overbank sediment/alluvial soil) samples will be collected at a density of 16 samples / 160kmX160km by jointly two parties. Samples will be delivered to China for analysis of 76 elements in China Labs. The selected samples shall be as the Iranian reference standards for the future national or regional geochemical mapping.* **Article 3 – Project Duration and Schedule** Section 1: Duration of Cooperation Project: The duration of this cooperation project is 5 years, from 2016 to 2020.	The comments are the same as for Argentina (see above) with a different comment with respect to the sampling density. In the case of Iran, the sampling density is 16 samples/160x160 km, which exceeds the GGB maximum recommendation of 8 samples /160x160 km. This sampling density implies that small catchment basins are sampled as there is doubt that within the grid cell of 25,600 km^2, 16 large catchment basins between 1000 to 6000 km^2 can be found.
Mexico (Agreement signed on the 22nd of October 2014)	**Article II: Scope of the Cooperation** Section 1 – Purposes of the Cooperation *Paragraph 1.2: To provide global-scale geochemical baseline data and maps of 76 elements to meet the approaches of the Global Geochemical Baseline Project.* Section 2 - Project Area: The working area of the Geochemical Mapping will cover the whole land of the United Mexican States in the Global Scale, and a portion of the Central Plateau for the National Scale. Section 3 – Cooperation Contents *Paragraph 3.2. Global Geochemical Baseline: Based on the Global Reference Networks (www.globalgeochemicalbaselines.eu), the Global Geochemical Baseline Project will be implemented across the whole territory of the United Mexican States by utilizing duplicate samples collected for NASGLP. Some Floodplain/overbank sediment samples could be resampled, if required, after a deep analysis of needs, at a density of 1 sample/80kmx80km in a typical catchment.*	The first comment is that the wide-spaced sampling and soil samples collected in the North American Soil Geochemical Landscapes Project do not follow the GGB specifications. Therefore, these samples cannot be analysed for 76 elements, and the data included in the Global Geochemical Baselines database. The second comment concerns the sampling density in the case that floodplain/overbank sediment samples will be taken. Again, the sampling density is 4 samples/160x160 km grid cell, instead of the GGB recommended minimum of 5 samples/160x160 km.

It is quite evident from the available information, extracted from the signed agreements, that the specifications of the Global Geochemical Baselines project of a systematic and consistent approach are not met with respect to sample type, sampling density and sampling method. It is indeed surprising that the sampling density varies from 1 sample/160x160 km in Ethiopia to 4 samples/160x160 km in Argentina, Nigeria and Ethiopia to 16 samples/160x160 km in Iran.

Many questions can be raised about these illogical inconsistencies. Answers can be found in the signed agreements, which show that China Geological Survey, the signatory from the Chinese side, is interested in the regional and more detailed geochemical surveys than the Global Geochemical Baseline mapping. The solution is that the UNESCO International Centre on Global-Scale Geochemistry must follow precisely the specifications as set by the IUGS Commission on Global Geochemical Baselines (see Section 6.4 and Paragraph 6.5.1, and the recommendation therein).

6.6. PARTICIPATION IN THE SECOND BLACK SOIL PROJECT WORKSHOP

The Sampling Committee chair is representing the Commission in the Global Black Soil Critical Zone Geo-ecological Survey (BASGES) project. The second Workshop was organised by the Shenyang Geological Survey in Harbin, a city in north-east China, from the 20th to the 24th of October 2018 (Fig. 5). The Commission's representative arrived in Harbin on the 18th of October 2018, and collaborated during the two days before the workshop with Dai Huimin and Liu Kai (Applied Geochemists of Shenyang Geological Survey, SGS). The first version of the Manual of Standard Geochemical Methods for the BASGES project was discussed (see Section 6.6.1), and all issues that needed attention were identified. Of course, the work on the manual started directly after the first workshop in December 2017, and was discussed electronically. However, the person-to-person discussion was needed in order to clarify several points and to identify the gaps.

Figure 5. Group photograph of the 2nd BASGES Workshop participants, Harbin, China.

Liu Kai (SGS) presented the work of the BASGES project Geochemistry Team entitled "*Geochemical mapping plan of Global Black Soil Critical Zones*" on behalf of the other team members, *i.e.*, Dai Huimin (SGS), Alecos Demetriades (IUGS CGGB), Geng Xiaoyuan and He Juanxia (Canadian Soil Information Service, Science and Technology Branch, Agriculture and Agri-Food Canada). Directly afterwards, Alecos Demetriades presented the first version of the Manual of Standard Geochemical Methods for the BASGES project, and the second version prepared (see Section 6.6.1). Points that needed attention were stressed, and the sampling of 4-mm thick surface soil for ground truthing of remote sensing spectra was discussed. It was finally

decided that the Remote Sensing team will be collecting the needed samples, and this part was removed from the second version of the Manual.

Outstanding issues are:

1. IUGS-CGGB-BASGES Geochemical Methods Manual (comments by all co-authors)
2. Equipment to be provided by project Coordinator to all participating countries
3. Project Reference Materials
4. Sample preparation
   4.1. Preparation of large solid blank reference sample
5. Analytical laboratory
   5.1. Determination of inorganic elements and other parameters
   5.2. Determination of pesticides and herbicides
   5.3. Determination of mineralogy

Upon receiving the comments and answers to the above issues the Manual will be finalised in the first quarter of 2019.

6.6.1. Manual of standard geochemical methods for the Global Black Soil project

The contents of the second version of the BASGES geochemical methods manual is given below. The co-authors list is still open.

BASGES PROJECT
MANUAL OF STANDARD GEOCHEMICAL METHODS

Alecos Demetriades, Dai Huimin, Liu Kai, Igor Savin, Manfred Birke, Ariadne Argyraki, Christopher C. Johnson, David B. Smith, Kate Knights, Patrice de Caritat, ……

6.6.2. Visit to Hailun Agricultural Ecological Station

On the 23rd of October 2018 the Hailun Agricultural Ecological Station (Chinese Academy of Sciences) was visited as it was important for the international members of the BASGES team project to familiarise themselves with black soil, human impacts due to intensive farming, and the experiments that are being carried out at this station (Figs. 6 to 8).

6.7. Annual General Meeting of the Organisation of African Geological Surveys

The Commission's Namibian member, Gloria Simubali, considered it important for a member of the Commission's Steering Committee to participate at the 11th Annual General Meeting of the Organisation of African Geological Surveys, O.A.G.S. (8-10 November, Dakar, Senegal) and to deliver a presentation about the need of Global Geochemical Baselines for Africa and the establishment of a Geochemistry Working Group similar to EuroGeoSurveys Geochemistry Expert Group.

Unfortunately, the Commission's financial situation was not in such a good standing, and it was, therefore, proposed to compile a PowerPoint presentation in collaboration with EuroGeoSurveys and for Gloria Simubali to present it. Gloria accepted this proposal, and directly afterwards this issue was discussed with the EuroGeoSurveys Secretary General, Dr. Slavko Solar, and the Chair (Philippe Négrel) and Deputy Chair (Anna Ladenberger) of the EuroGeoSurveys Geochemistry Expert Group.

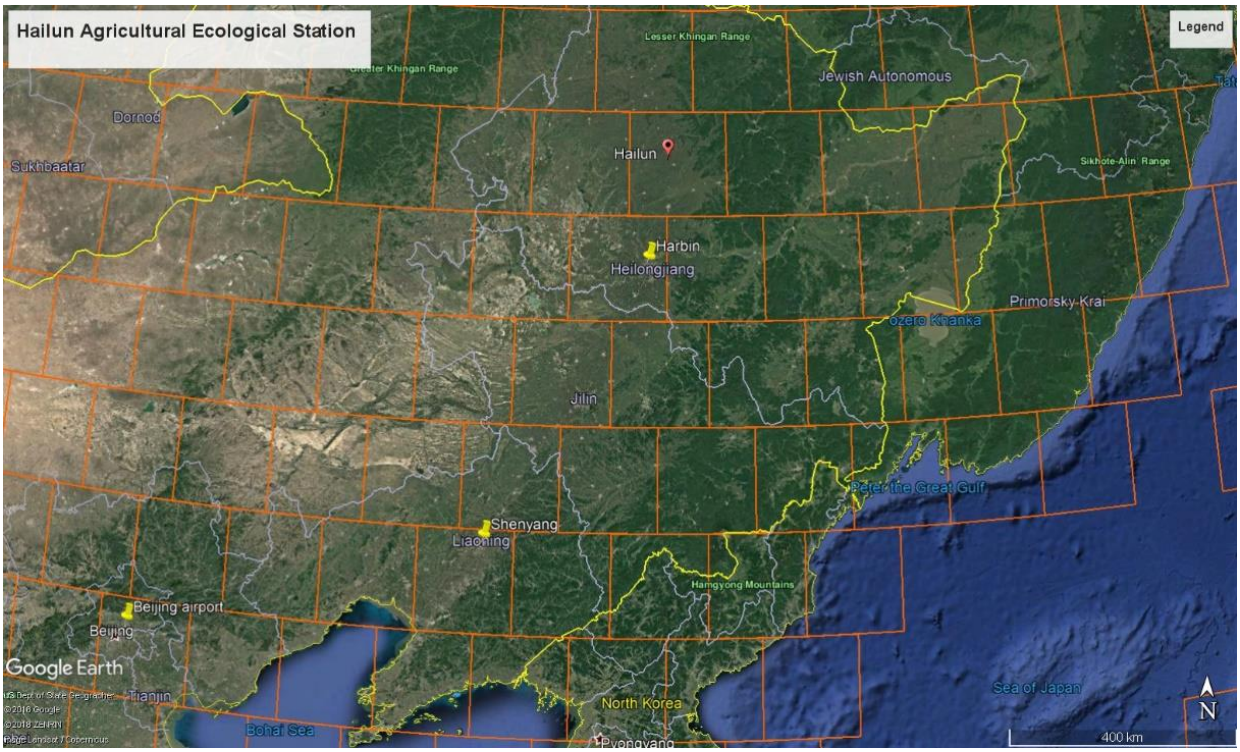

Figure 6. The City of Hailun and Hailun Agricultural Ecological Station in relations to Shenyang and Beijing, China. The Global Terrestrial Network of 160x160 km is shown with red colour squares (Source: Google Earth).

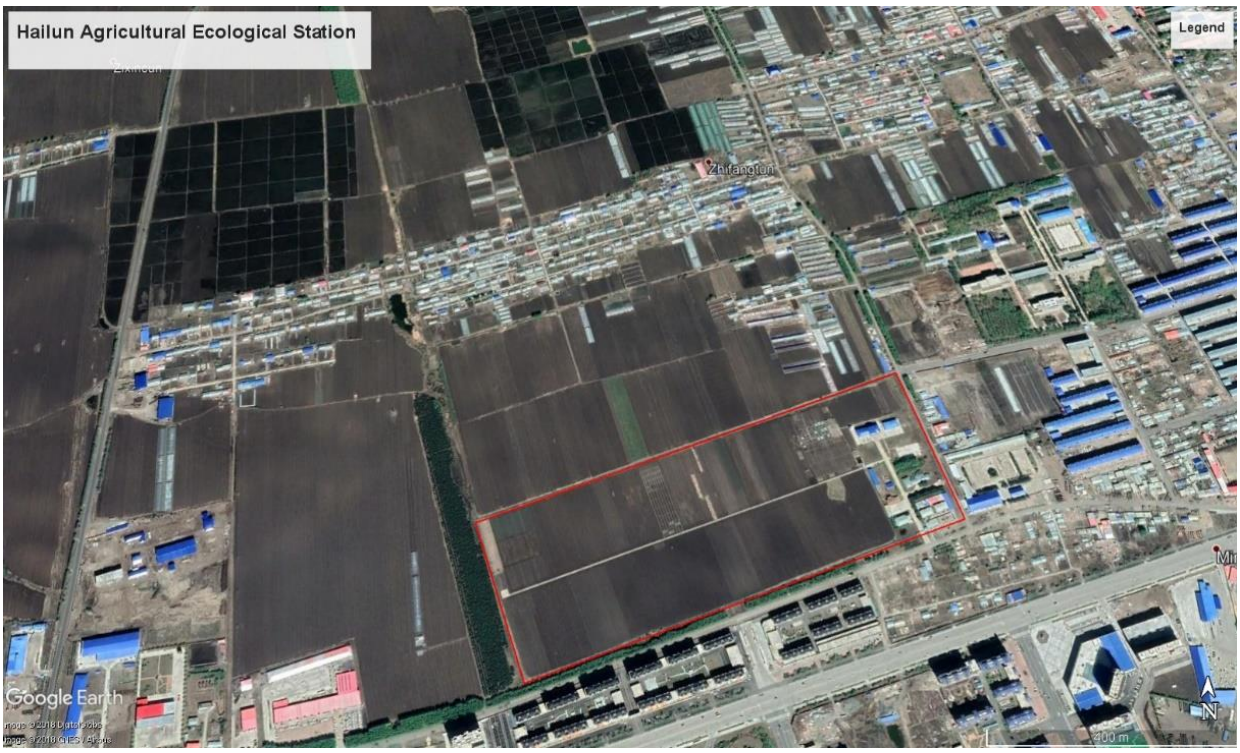

Figure 7. Hailun Agricultural Ecological Station (marked with red colour rectangle); note the black soil of recently ploughed fields to the N & NW of the Station (Source: Google Earth).

(a) (b)

Figure 8. (a) Agricultural field with black soil; (b) Close-up of black soil, Hailun Agricultural Ecological Station.

The title of the PowerPoint presentation was: '*Africa Global-scale Geochemical Baselines for mineral resource and environmental management: Establishment of an O.A.G.S. Geochemistry Working Group, and Capacity-building phase*'. Gloria Simubali delivered the presentation, and according to the information received the O.A.G.S. decision is to establish a Geochemistry Working Group. The Commission will be assisting Gloria Simubali in this effort.

6.8. GLOBAL GEOCHEMICAL REFERENCE NETWORK

As stated by Darnley *et al.* (1995) in order to begin systematic international geochemical mapping, it is necessary to establish a primary global Geochemical Reference Network (GRN), analogous to a geodetic grid. The primary global GRN is based on the Global Terrestrial Network or Geochemical Terrestrial Network (GTN) grid cells of 160x160 km. Up to now these terms were used as synonyms. However, it is here important to explain the difference among (i) the *Global Reference Network*, (ii) the *Global Terrestrial Network* or *Geochemical Terrestrial Network* (GTN) and (iii) the global *Geochemical Reference Network* (GRN):

(i) The *Global Reference Network* refers to the grid cells of 160x160 km covering the whole globe (land and sea);
(ii) The *Global Terrestrial Network* or *Geochemical Terrestrial Network* (GTN) refers to the grid cells of 160x160 km covering only the terrestrial part of the globe, and
(iii) The global *Geochemical Reference Network* (GRN) refers to the individual sampling sites within each GTN grid cell of 160x160 km.

Therefore, the GTN grid cells of 160x160 km are used for the generation of 5 or 8 random points within each grid cell, which assist in the selection of the nearest small second order catchment basin of <100 km^2 and its adjoining large third order catchment basin of 1000 to 6000 km^2. From the small second order catchment basin the following sample types should be taken:

- Active stream sediment or lake sediment
- Stream water (if present)
- Overbank sediment (top and bottom)
- Residual soil (top and bottom)
- Humus (if present), and
- Rock (will be added in the under-compilation manual of standard geochemical methods).

While from the large, third order or higher catchment basin, only floodplain sediment samples (top and bottom) should be taken.

By collecting systematically, the aforementioned sample types from all GTN grid cells of 160x160 km, a global Geochemical Reference Network will be established for each one. These sample types, apart from their use in levelling the data of more detailed national regional geochemical surveys, will be used as secondary analytical reference materials to standardise future geochemical work in each country. Hence, according to the recommendation by Darnley *et al.* (1995) adequate quantities must be obtained and retained.

The problem with the management of the UNESCO International Centre on Global-Scale Geochemistry is that they have not understood the significance of planning efficiently and systematically the sampling campaign for the establishment of the global Geochemical Reference Network for all recommended sample types. *For example*, by using only floodplain sediment, the data obtained are of limited value, because they cannot be closely correlated with, nor provide reference materials for, the sampling media commonly collected in detailed national regional surveys, and that the objective for the establishment of the global Geochemical Reference Network is to provide sufficient data for all recommended sample media in order to link geochemical mapping at all scales (Darnley *et al.*, 1995). Further and, most importantly, the result of the decision to collect only floodplain sediment would be to increase the cost of the overall project due to the necessity to revisit every GTN grid cell at a later date to collect the other recommended sample types. It is again stressed that the other sample media are important in order to provide reference materials for surveys at the national level, and more clearly indicate the range of abundance variations in the geochemical background (Darnley *et al.*, 1995). It is, therefore, prudent for the UNESCO International Centre on Global-Scale Geochemistry to change completely its approach by:

- Firstly, encourage all participating countries to collect all recommended sample media, which, after sample preparation can be safely stored for analysis at a future date, and
- Secondly, change completely the planning of the *ad hoc* selection of individual countries in different continents because this approach does not provide the continental-scale patterns, and to plan a systematic approach by convincing all countries of a continent to participate in the project at the same time, *i.e.*, South and Central America, Africa, Asia, *etc.*

with the aim to establish the global Geochemical Reference Network, as it was done in Europe with the FOREGS Geochemical Atlas with 26 countries participating at the same time in the project.

6.8.1. Global Terrestrial Network (GTN)

The original database of the Global Terrestrial Network or Geochemical Terrestrial Network (GTN) of 160x160 km grid cells covered the terrestrial part of our home planet Earth with 5711 grid cells (Fig. 9). Coastal parts where the centre of the 160x160 km grid cell fell in water (ocean, sea, lake) were deleted from the database, and this action also affected most islands. The problem was discovered in 1997 during the planning of the FOREGS Geochemical Atlas of Europe project, and at the time it was corrected only for the European part. As more countries are interested in participating in the Global Geochemical Baselines project, it is important to correct this problem of missing coastal and island grid cells.

The original GTN grid cells database was generated at the Geological Survey of Finland and, therefore, Timo Tairvanen (Chair of Data Management Committee) was contacted, but he only had the database with 5711 grid cells. Afterwards Robert G. Garrett (Geological Survey of Canada) was contacted at the beginning of August 2018, and although retired, he fortunately kept the original file of 160x160 km grid cells covering the whole globe (land and sea), which was generated in 1994 by Nils Gustavsson (Geological Survey of Finland), and consisted of 19,833 grid cells of 160x160 km. Alecos Demetriades (Chair of Sampling Committee)

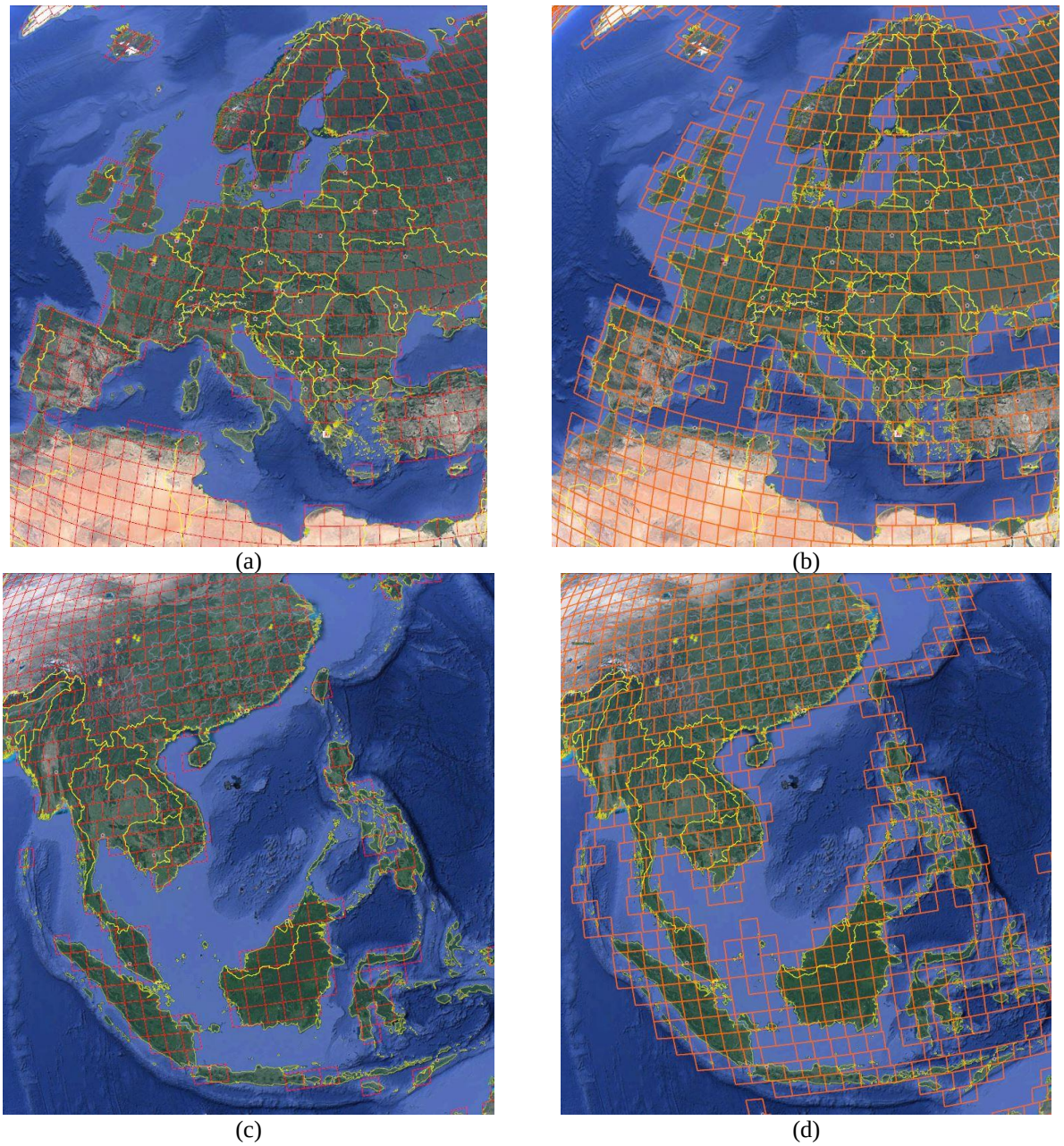

Figure 9. Google Earth images of GTN grid cells of 160x160 km over Europe, North Africa and SE Asia and Indonesia (a) & (c) the original database of 5711 grid cells with many missing grid cells, and (b) & (d) new database of 7356 grid cells showing complete coverage.

superimposed the two files of 5711 and 19,833 grid cells, located all missing grid cells and copied their grid cell reference number and country name in a Microsoft Excel worksheet; in total, 1645 missing grid cells were found. Afterwards a software program for extracting the corner and centre coordinates from the 19,833 grid cell database, compiled by Euripides Vassiliades (retired computer programmer of the Hellenic Institute of Geology and Mineral Exploration), was used, and subsequently a new GTN grid cells database was generated with 7356 grid cells of 160x160 km (August-September 2018). The Microsoft Excel databases of 19,833 and 7356 grid cells of 160x160 km can be downloaded from the Commission's website, *i.e.*,

- Global Reference Network of 19,833 grid cells of 160x160 km, and
- Global Terrestrial Network of 7356 grid cells of 160x160 km.

Further, the corresponding Google Earth *.kml files were generated, and they can be downloaded from the Commission's website in *.zip format:

- Global Reference Network of 19,833 grid cells of 160x160 km, and
- Global Terrestrial Network of 7356 grid cells of 160x160 km.

6.8.2. Generation of random points in the Global Terrestrial Network grid cells

Geng Xiaoyuan and Juanxia He (Canadian Soil Information Service, Science and Technology Branch, Agriculture and Agri-Food Canada, http://sis.agr.gc.ca/) have undertaken the task to generate the 5 and 8 random points within each GTN grid cell of 160 x 160 km (September-November 2018). The reason for generating two different files, with 5 and 8 random points, respectively, in each 160x160 km grid cell, is that these two options are given in the "*The Blue Book*" (Darnley *et al.*, 1995, p.2 and 44), and countries are free to select which sampling density will be using. In the FOREGS Geochemical Atlas of Europe project, the 5 random point option was selected as is more cost- and time-efficient.

Besides the generation of databases for 5 and 8 random points within each GTN grid cell of 160x160 km, it was decided during the October 2018 meeting of the Scientific Committee of the UNESCO International Centre on Global-Scale Geochemistry to generate another database for 16 random points within each GTN grid cell of 160x160 km. This is for countries wishing to carry out higher sampling density wide-spaced geochemical surveys using a random design, which are not related to the global Geochemical Reference Network project.

In the case of the 5 point random sampling design (see Fig. 10a):

- point number 1 is in the NE quadrant of the GTN grid cell,
- point number 2 in the NW quadrant,
- point number 3 in the SW quadrant and
- point number 4 in the SE quadrant.

Point number 5 is randomly located in the GTN grid cell (see Fig. 11).

In the case of the 8 point random sampling design, there are 2 random points in each quadrant of the GTN grid cell (see Fig. 10b):

- point numbers 1 & 2 are in the NE quadrant of the GTN grid cell,
- point numbers 3 & 4 are in the NW quadrant,
- point numbers 5 & 6 are in the SW quadrant, and
- point numbers 7 & 8 are in the SE quadrant.

In the case of the 16 point random sampling design, there are 4 random points in each quadrant of the GTN grid cell (see Fig. 10c):

- point numbers 1, 2, 3 & 4 are in the NE quadrant of the GTN grid cell,
- point numbers 5, 6, 7 & 8 are in the NW quadrant,
- point numbers 9, 10, 11 & 12 are in the SW quadrant, and
- point numbers 13, 14, 15 & 16 are in the SE quadrant.

It is again stressed that the 16 point random sampling design is not for use in the Global Geochemical Baselines project.

The following files can be downloaded from the Commission's website:

- Microsoft Excel Workbook of 5 randomly selected points in each GTN grid cell of 160x160 km;
- Google Earth *.kml file of 5 randomly selected points in each GTN grid cell of 160x160 km (in *.zip format);

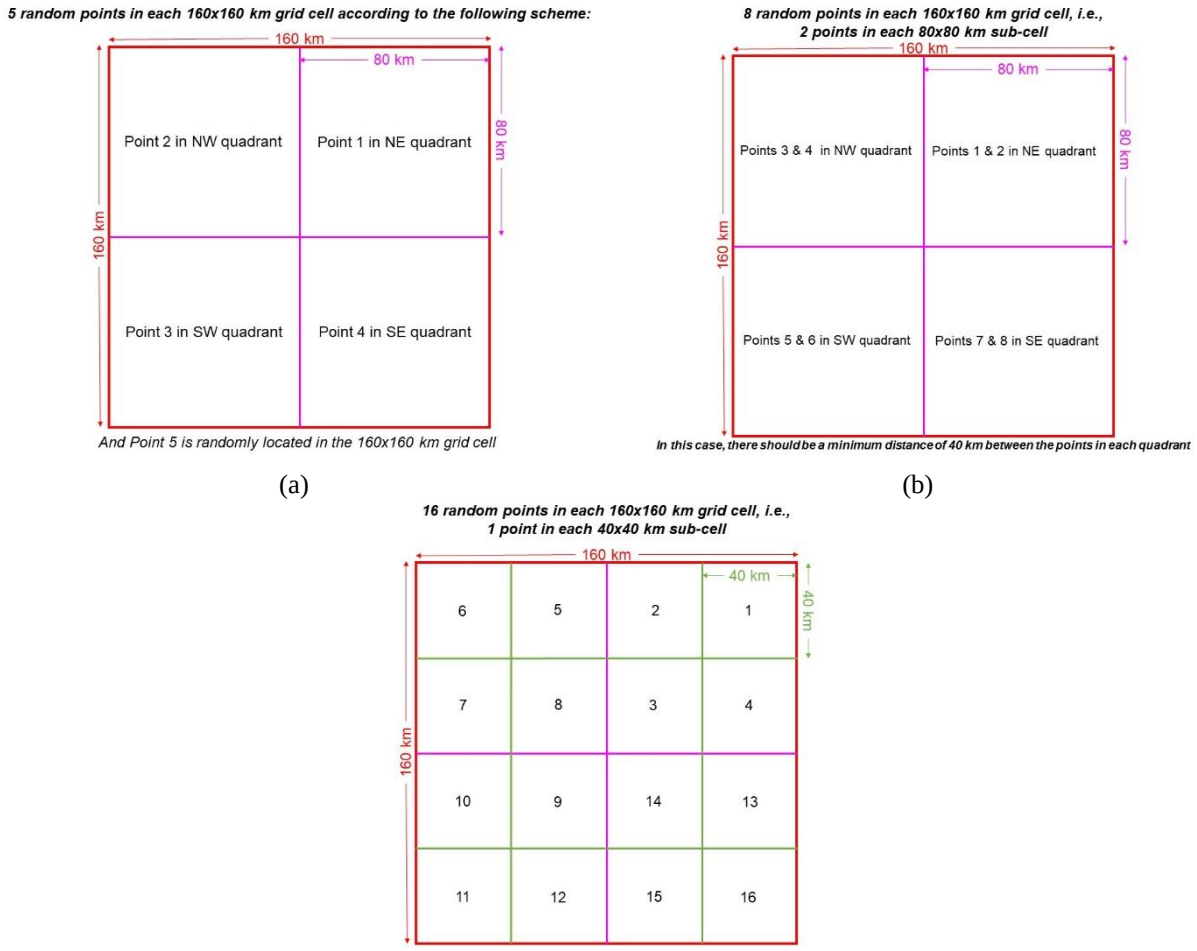

Figure 10. Random sampling designs for (a) 5 points, (b) 8 points and (c) 16 points in each grid cell of 160x160 km.

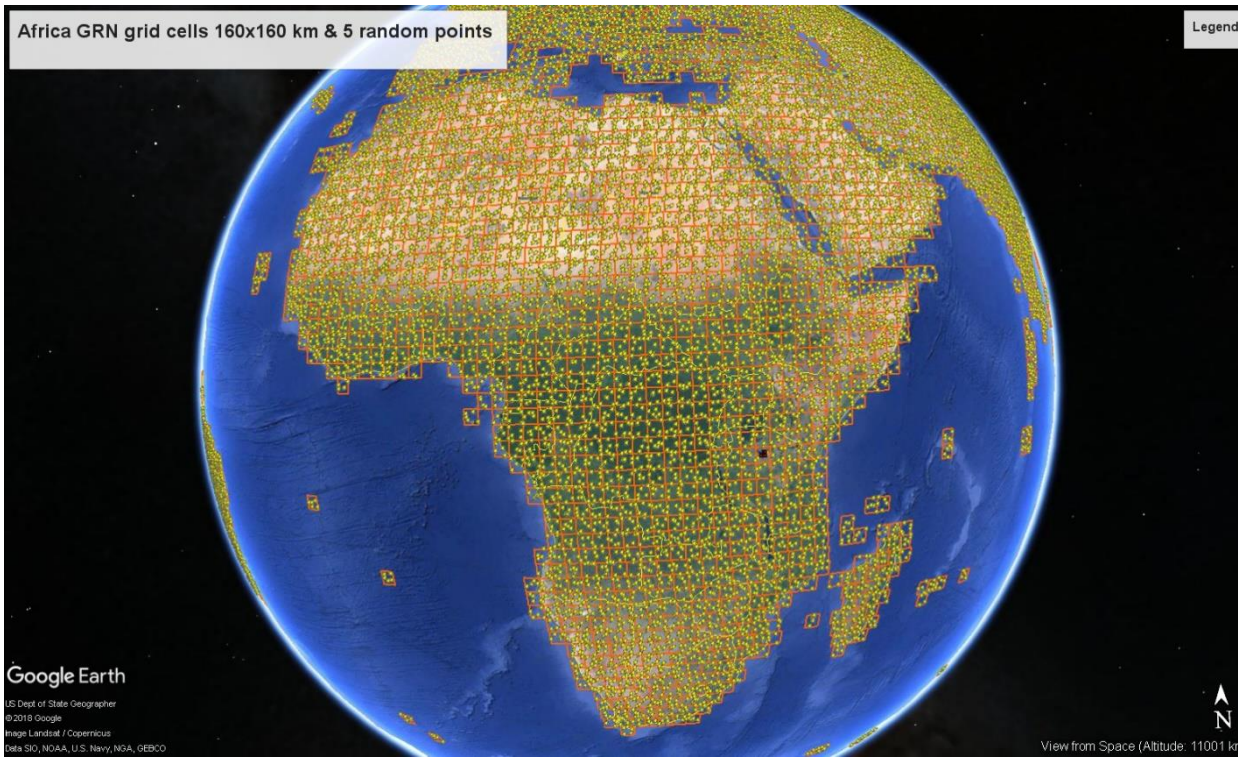

Figure 11. Google Earth image of Africa and Middle East countries showing the 5 random points in each grid cell of 160x160 km.

- Microsoft Excel Workbook of 8 randomly selected points in each GTN grid cell of 160x160 km;
- Google Earth *.kml file of 8 randomly selected points in each GTN grid cell of 160x160 km (in *.zip format);
- Microsoft Excel Workbook of 16 randomly selected points in each GTN grid cell of 160x160 km (*not recommended for the global Geochemical Reference Network*), and
- Google Earth *.kml file of 16 randomly selected points in each GTN grid cell of 160x160 km (*not recommended for the global Geochemical Reference Network* – in *.zip format).

6.9. REDESIGNING OF COMMISSION'S WEBSITE

Considerable time was devoted on the collaboration with the Web-hosting and Web construction company on the redesign of the Commission's new Website. The reason was that a new bi-lingual (Hellenic-English) user-friendly platform was used, and all the Hellenic text had to be removed, and the original design formats modified. After reviewing the needs of Social Media, it was decided to use experimentally 'facebook' (https://www.facebook.com/CGGBIUGS; @CGGBIUGS) and 'Twitter' (https://twitter.com/CGGB_IUGS; @CGGB_IUGS), and to upload the sampling video films to YouTube. The work was completed in December 2018, and the new website was uploaded on the 17th of January 2019 (http://www.globalgeochemicalbaselines.eu/).

6.10. COMMITTEES' WORK

During 2018 members of the Sampling, Analytical and Data Management Committees were and still are busy in the writing of the relevant chapters of the 'International Union of Geological Sciences Manual of Standard Methods for Establishing the Global Geochemical Reference Network' (see Section 6.4).

The Public Relations and Finance Committee's main work was the redesigning of the Commission's website in collaboration with the hosting company's designers (see Section 6.8). Further, is exploiting a few options for obtaining sponsorships.

6.11. ASSISTANCE TO MEMBERS AND WORKSHOP PARTICIPANTS

Assistance was provided to Commission members from Morocco, Brazil, Chile, China and Namibia, which concerned mainly the supply of the Global Terrestrial Network grid cells of 160x160 km, and random sites. One question concerned the display of geochemical data on maps, and the advice was to follow the map design of the FOREGS Geochemical Atlas of Europe (Tarvainen *et al.*, 2005). Letters of support were provided for Ph.D. application to a D.R. Congo and Iran attendees of the YES Network Workshops in Tanzania and Iran, respectively.

6.12. PUBLICATIONS

At the request of Otavio Augusto Boni Licht (Associate Professor of Postgraduate Programme in Geology, Laboratory of Hydrogeological Research, Federal University of Paraná, Curitiba, Paraná, Brazil), as the Guest Editor of a special issue of Geochimica Brasiliensis on Geochemical Mapping (http://www.geobrasiliensis.org.br), members of the Commission's Steering Committee have written two papers. These were submitted by the end of May 2018, and were published on-line on the 21st December 2018. Both papers can be downloaded from the journal's website:

Smith, D.B., Demetriades, A., Caritat, P. de, Wang, X., 2018. *The history, progress, and future of global-scale geochemical mapping*. In: Licht, O.A.B. (Guest Editor), Geochemical

Mapping. Special Issue, Geochimica Brasiliensis, 32(2), 115-135; http://doi.org/10.21715/GB2358-2812.2018322115.
Demetriades, A., Smith, D.B., Wang, X., 2018. *General concepts of geochemical mapping at global, regional, and local scales for mineral exploration and environmental purposes*. In: Licht, O.A.B. (Guest Editor), Geochemical Mapping. Special Issue, Geochimica Brasiliensis, 32(2), 136-179; http://doi.org/10.21715/GB2358-2812.2018322136.

7. REGIONAL REPORTS

Regional reports were provided from Africa, South America (Chile, Colombia), North America (United States of America), Asia (China, Japan), Australasia (Australia and New Zealand), and Europe. These reports are in Appendix 3.

8. NEW MEMBERS

In 2018, the Commission had 24 new members, which come from 14 countries, *i.e.*, Austria (1), Armenia (2), Canada (2), Chile (1), Denmark (1), Estonia (1); Finland (2), Hellas (5), Iran (3), Ireland (1), Morocco (1), Namibia (1) and Spain (2) and United Kingdom (1). In total, the Commission has 137 members in 58 countries (see Members list in Commission's web page).

9. USAGE OF IUGS ALLOCATION

Usage of allocated 2018 fund of US $4000 and outstanding balance of US $10,289.71 is tabulated in Table 3 below. To the aforementioned figure, the following amounts should be added: (i) US $52.61, which is a surplus from the reimbursement by GeoScience Australia of Patrice de Caritat's (Scientific Secretary) return airline ticket from Canberra to Vancouver for RFG2018, and (ii) US $4.79, which is the earned 2018 interest after deducting tax. Hence, the total amount available for 2018 expenses is: **US $14,347.11**.

Table 3. Expenses incurred during 2018.

Event / Category	Cost description	Cost in US $
IUGS annual allocation fund	Bank charges	3.59
72nd IUGS EC meeting, GFZ Potsdam, Germany (22-24 January 2018). Participation and reporting by Commission Treasurer of the 2017 work, and 2018 schedule	Return airline ticket (Athens-Berlin)	315.37
	Hotel	414.86
	Other expenses (travel insurance, local travel, food)	132.88
Joint Business Meeting of EuroGeoSurveys Geochemistry Expert Group and IUGS Commission on Global Geochemical Baselines, Geological Survey of Spain (16-19 May 2017). Participation and reporting of Chairs of Sampling and Public Relations & Finance Committees	Two return airline tickets (Athens-Madrid)	1070.58
	Hotel (2 single rooms)	1068.10
	Daily allowance for food expenses at 50 USD/day for two people	500.00
	Other expenses (travel insurance, local transport)	303.03
RFG2018 Conference, Vancouver, Canada. Participation of 1st Co-chair, Treasurer & Sampling Committee Chair, and Scientific Secretary	RFG2018 Registration fees for 3 people (D.B. Smith, P. de Caritat, A. Demetriades)	1026.97
	Abstract submission fee for 3 abstracts	113.63
	Airline tickets (D.B. Smith)	795.94
	Vancouver Hotel (3 single rooms)	4598.75
	Daily allowance for food expenses at 50 USD/day for three people [D.B. Smith (5 days); P. de Caritat (9 days; A. Demetriades (9 days)]	1150.00

Event / Category	Cost description	Cost in US $
	Other expenses (*e.g.*, travel insurance, transportation to and from airports, Canadian ETA Service fees, *etc.*)	319.63
Participation of Treasurer & Sampling Committee Chair at (i) 2nd meeting of Governing Board and Scientific Committee of the UNESCO International Centre on Global-Scale Geochemistry, Langfang, China, and (ii) 2nd BASGES Workshop, Harbin, China	Issue of Visa by Chinese Embassy, Travel insurance, local transportation to and from airport (Athens, Greece), suitcase wrapping, and coffee/snack at airports	273.41
Website hosting fee (2018-2019)		273.26
Bank transfer charges	For sending expenses incurred by 1st Co-chair (D.B. Smith in RFG2018)	68.43
Simply Fortran software to convert necessary statistical programs from MS-DOS Fortran 77/Power Station 4 to 32- and 64-bit Windows platform, and made freely available through the Commission's website. These include a robust analysis of variance program ROBCOOP4 (Ramsey, 1998) and a library of programs by Davis (1973)	Purchase of Simply Fortran for one computer, and a year subscription to the library programs	176.97
Participation of Treasurer at 73rd IUGS EC meeting in Beijing (February 2019)	Airline ticket Athens-Beijing-Athens	872.21
	Total 2018 expenses (US $):	**13,477.61**

As is shown in Table 3, the total 2018 expenses are US $13,477.61, and the outstanding balance in the Commission's bank account is: US $869.50.

9.1. IUGS FUNDING FROM 2003 TO 2018

Funding from IUGS has consisted of US $1500 per year for 2003 to 2008; US $4000 for 2009 and 2010; US $5000 for 2011 and 2012; no funding for 2013; US $5000 for 2014, 2015 and 2016; US $4500 for 2017, and US $4000 for 2018.

10. FUNDING REQUEST FROM IUGS FOR 2019 & FIRST QUARTER OF 2020

The main Commission tasks in 2019 that require no funds are:

(i) Completion of the '*International Union of Geological Sciences Manual of Standard Methods for Establishing the Global Geochemical Reference Network*' (planned to be completed by the end of June 2019, subject to the voluntary input by all the people that are involved in this very important reference work (see Section 6.4));

(ii) Completion of the '*BASGES Project Manual of Standard Geochemical Methods*' (planned to be completed by the end of March 2019, provided that Shenyang Geological Survey supplies all necessary information as outlined in Section 6.6.1);

(iii) Conversion of statistical programs from MS-DOS Fortran 77/Power Station 4 to 32- and 64-bit Windows platform, and made freely available through the Commission's website. These include a robust analysis of variance program ROBCOOP4 (Ramsey, 1998) and a library of programs by Davis (1973);

(iv) Preparation of conference presentations, and workshop material;

(v) Updating the Commission's website, and

(vi) Providing assistance and information to requests from different geological surveys and individuals, especially participants in workshops.

Taking into account the following planned activities in 2019:

- Participation in the 73rd IUGS Executive Committee meeting in Beijing (February 2019);
- Making short video films to show the sampling procedures, as it is impossible to train all the national sampling teams, which will be involved in the establishment of the Global Geochemical Reference Network;
- Participation in the International Congress of the Geological Society of Greece (22nd to 24th May 2019, Athens) with a session entitled '*Geochemical mapping for environmental and resource management*' (T4.S1), and a one-day Workshop on '*Global-Scale Geochemical Mapping'*, https://www.gsg2019.gr/;
- Participation in the International Symposium on Environmental Geochemistry (7th to 10th August 2019, Peking University, Beijing, China) with a session entitled '*Regional and Global Geochemistry: Opportunities and Challenges*', http://webues.pku.edu.cn/iseg2019, followed by a two-day workshop on Applied Geochemistry at Shangluo Institute, Shangluo near Xi'An, Shaangxi Province, China;
- Participation in the 5th YES Congress with a three-day workshop on '*Applied Geochemistry and Global Geochemical Baselines*' (Freie Universität Berlin, Berlin, Germany, 9th to 13th September 2019), https://yesdeutschland.weebly.com/; the two-days of lectures will be on the 7th and 8th of September 2019, and the field training workshop on the 14th of September 2019;
- Participation in the 3rd BASGES Workshop organised by the Shenyang Geological Survey in the autumn of 2019;
- Organisation and participation in the two-day autumn annual joint business meeting of the Commission and the EuroGeoSurveys Geochemistry Expert Group, which will be on the 26th and 27th September 2019, and hosted by the Mining and Geological Survey of Hungary, Budapest, and
- Organisation and participation in a dedicated session at the 36th International Geological Congress in Delhi (2nd to 8th March 2020) entitled '*4th Arthur Darnley Symposium: Challenges and opportunities of Global-scale geochemical mapping*',

it is anticipated that the expenses for 2019 could reach US $8300 (Table 4), and the expenses for the first quarter of 2020 are estimated at US $4,800 (Table 5). In the 2019 budget, an amount in the order of 5000 US$ for training workshops in Africa should have been included.

Table 4. Estimated expenses for 2019.

Event category	Cost in US $
73rd EC meeting, Beijing, China (26-28 February 2019); Participation of Treasurer for reporting Commission's 2018 activities, and 2019 work plan. Costs: Travel insurance, local travel to and from airport	200.00
Video filming of sampling techniques: Hire of 4-wheel vehicle for 5 days with a comprehensive insurance (≈450 US $); petrol (≈300 US $); sandblasting of equipment (≈50 US $); unforeseen expenses (≈100 US $)	900.00
Participation in the International Congress of the Geological Society of Greece (22-24 May 2019, Athens, Hellas). Registration fees for two persons	300.00
Participation in ISEG, Peking University, Beijing (7-10 August 2019), and Shangluo Institute, Xi'An, China (12-13 August 2019). Costs for one person: Travel insurance and local travel to and from airport (Note: all other expenses will be paid by ISEG and Shangluo Institute)	100.00
Organisation of Workshop on "*Applied Geochemistry and Global Geochemical Baselines*", 5th YES Congress, Freie University, Berlin, Germany (7-14 September	3350.00

Event category	Cost in US $
2019). Costs for two participants (return airline tickets, travel insurance, transport to and from airport, hotel and daily allowance for food)	
Participation in the 3rd BASGES Workshop, China. Costs of one person attending (Visa, travel insurance, transport to and from airport (Note: All other expenses will be paid by Shenyang Geological Survey, China).	180.00
Participation in the two-day annual business meeting of the Commission, Budapest, Hungary. Costs of two people attending (return airline tickets, travel insurance, transport to and from airport, hotel and daily allowance for food)	2600.00
Website hosting fee 2018-2019, and additional space on server	500.00
Total estimated expenses in US $ for 2019:	**8253.60**
Outstanding balance (US $) in Commission's bank account at the end of 2018:	**869.50**
Estimated minimum amount (US $) required to cover 2019 expenses:	**7384.10**

Table 5. Estimated expenses for participation in the 36th IGC in Delhi, India (expenses for the first quarter of 2020).

Event category	***Cost in US $***
Participation in the 36th IGC Congress, Delhi, India, and chairing the session '*4th Arthur Darnley Symposium: Challenges and opportunities of Global-scale geochemical mapping*'. Costs for two people attending: return airline tickets, travel insurance, transport to and from airport, hotel, daily allowance for food and registration fees	4800.00
Total estimated expenses in US $ for the 1st Quarter of 2020:	**4800.00**

The Commission is, therefore, requesting financial support from IUGS in the order of:

- US $ 8,000 for the 2019 planned work and commitments (Table 4), and
- US $5,000 for the first quarter of 2020 to cover the expenses for its participation in the 36th IGC in Delhi, India, with a session (Table 5).

It should be mentioned that in the 2019 budget (Table 4), the cost of training workshops in Africa is not included, as this depends on the availability of funds from IUGS.

11. LINK TO IUGS WEBSITE

The Commission's website has a link to the IUGS website through its logo, which is displayed on all web pages, and also in the Links web page at http://www.globalgeochemicalbaselines.eu/content/104/links-/.

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Note: *All web links checked on the 20th of January 2019.*

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APPENDIX 1: MINUTES OF THE ANNUAL BUSINESS MEETING

The minutes were prepared by Anna Ladenberger, Deputy chair of EGS GEG

Wednesday, 16th May 2018

09:00-09:10: Registration of all meeting participants
09.10: Welcome

Welcome by D. Santiago Martin Alfageime (Head of Technical Cabinet) on behalf of the IGME Director Dr. Francisco Gonzalez Lodeiro.
Welcome from Chairman of the EGS Geochemistry Expert Group (GEG) Clemens Reimann

9.15. Minutes of 2017 meeting presented by Philippe Négrel and accepted by the members.

9.20. Report about EGU 2017/18 (Philippe Négrel)
At EGU 2017 the session SSS3 '*Geochemical mapping at all scales*' was organised by GEG, with Philippe Négrel and Edith Haslinger as conveners.
The session accommodated:

- 24 abstracts
- 7 oral, and 13 poster presentations.

EGU 2018 - one session for critical zone and geochemical mapping was organised with 45 abstracts (17 oral, 28 posters) and Philippe Négrel and Jasper Griffioen as conveners. Due to many abstracts received, we obtained one of the big meeting rooms and a full-day time slot.
Altogether, EGU 2018 had 15 000 participants from 112 countries. There is a request for a session in 2019, since the topic seems to be well established now and hosts many participants.

9.30. - 2017 GEG activities (Clemens Reimann)

- GEMAS presented at several meetings, *e.g.*, Cost Action TD 1407, Israel, January 2017, Goldschmidt Conference 2017 in Paris.
- Please send information to Alecos about your activities: talks, presentations, workshops, meetings, courses organised and participation, because these are required for the half year and annual reports. These are made available to everybody through pCloud, and new presentations can easily be compiled.
- Report to EGS National Delegates (ND):
  - ✓ Last meeting in Vienna 30-years of GEG plus EGU 2017.
  - ✓ 50 members from 30 European countries, ca. 20 active.
  - ✓ Around 40 external people cooperating with the group in different projects: wanted or not? Should we have external collaborators? The majority opinion is Yes, we should! It is crucial for networking and covering the European continent. ND admitted that we profit from this external collaboration.
  - ✓ Mission and vision must be defined, summary in the report.
  - ✓ GEG has two co-chairs, and quite recently established contact persons with other expert groups – this was well received by the NDs. A problem exists, however, with their participation in the meetings of the other groups because travel money is missing.
  - ✓ Contact persons should go to the meetings of other groups to keep the network going.
  - ✓ The establishment of a new URBAN geology group was decided at the ND forum – this was a controversial issue in the view of all other expert groups because whatever the urban geology group does will in a way interfere with what the established expert groups are already doing (*e.g.*, urban geochemistry and the URGE project(s) in case of the GEG). The expert groups were thus of the opinion that an urban geology project, where

all expert groups cooperate would be the better way to proceed than establishing a new expert group.

- ✓ The ND forum decided that Philippe Négrel will become the new chair following the 2018 group meeting in Madrid. The NDs and the EGS Executive Committee thanked Clemens Reimann for 12 years of service.

- EGG project - almost 1000 copies of the book sold, many positive comments, 34 publications (EGS published a water book without citing the European scale EGG book)
- URGE: 620 copies of the book sold;
- The special issue of the Journal of Geochemical Exploration '*Urban Geochemical Mapping: The EuroGeoSurveys Geochemistry Expert Group's URGE project*' with 13 papers is online and the printed version became available in April 2018 (https://www.sciencedirect.com/journal/journal-of-geochemical-exploration/vol/187). The EGS logo is displayed on the front page. Comment by AD: This is a good promotion of GEG and EuroGeoSurveys activities.
- URGE II still needs financing, sampling manual was ready in 2015 and is published as an EGS publication (http://www.eurogeosurveys.org/wp-content/uploads/2015/06/EGS_Urban_Topsoil_Geochemical_Mapping_Manual_URGE_II_HR_version.pdf). URGE II could be started any time if sufficient number of surveys decides that they want to do this.
- GEMAS atlas: ca 700 copies sold, by now we have reached 70 partners, people still contacting CR and willing to do new research on data or samples. This is one of the biggest projects we ever had, visible all around the world, it shows the power of the group for the network building. One example of such networking was that the big continental-scale geochemical surveys exchanged standards to make data better comparable at the global scale: GEMAS, U.S.A. (Smith *et al.*, 2013), China (Xueqiu Wang *et al.*, 2015), Australia.
- 2017: 7 new GEMAS publications, 35 articles in total!
- Invited GEMAS talk at the Goldschmidt Conference 2017 in Paris (Clemens Reimann)
  An emerging problem: many review articles on 'Element X in the environment" do not cite GEMAS! Examples in 2017 were an article on Tl and an Article on Cr. Such articles would require a critical comment – but who will write it? Patrice de Caritat and Clemens Reimann wrote such a comment to the Tl article but not any longer to the Cr article because it is just too much work.
- One problem may be the rather poor visibility of GEMAS online! The possible reasons: not enough communication, better website, with service, better address, more information about events and places where GEMAS is presented, more updates; How? and at what Cost?
- May be BGR can make a new website next year, but now they have some budget problems.
- Better promotion of GEMAS is still needed, time flies and the project is getting old.
- More attention at the local scale, we are far ahead of other groups in collaboration skills. Small groups working together – becomes more important and maybe more practical solution for the next few years.
- The GEG involvement into GeoEra was not successful so far – GeoEra requires a lot of bureaucracy.

Project ideas (Interesting ideas, but no money!):

1. Tap- surface -spring- water geochemistry: not all surveys can finance the sampling. GeoEra meeting in Warszawa showed that the survey is too expensive; surveys are paying 2/3rd of project costs. Other problems: too much administration, too short time; a problem with competition with the WREG. Clemens Reimann and Belinda Flem met Eurometaux, which was very promising, ca 250 000 Euro was offered to GEG. Unfortunately, in GeoEra industrial partners who pay parts of the work are not welcome.
2. Lithogeochemistry
3. URGE II
4. Continental Shelf

5. Ocean Basin
6. Coal and oil
7. GEMAS for remote sensing, contacts with ESA
8. Further GEMAs analyses, mineralogy, new isotopes, DNA

10:30-11:00 Working Coffee break

11.00. GEG Activities - CR continues:

- Evaluation of the expert groups by EGS. All other expert groups shall follow the Energy Expert Group example and make their own Roadmap and Strategy for the three pillars.
- We are most active in pillar 3: yearly events, *e.g.*, EGU, professionalised events. Pillar 2 – harmonised data (*e.g.* GEMAS, FOREGS, EGG). Pillars 1- contacts with DG Environment, two presentations given by CR; competition with JRC handicapped our contacts with DG Environment.
- How much time can we devote to policy making? Pillar 1?
- Our relationship with JRC in the future: JRC soil group has a new leader and we need to sign a new collaboration agreement. Shall we suggest a common workshop with JRC about LUCAS and GEMAS projects? Another topic could be discussed with JRC - lithological map of Europe.
- Timo reported that environmental reports in Finland use JRC reports for soil data.
- More visits to EEA (located in Copenhagen), DG ENV, letter of supports might help to get funding from various sources.
- Advice from Gyozo: good way is to provide an official database for EEA, then all environmental organisations will use it via EEA webpage. A way of getting the funding is an update of such database. IMPORTANT! A problem may be the source reference for GEMAS while on EEA database – we do not want to lose the visibility.

11.35-11.45. Tour de table

11.45-12.15. 2017 IUGS CGGB activities (Alecos Demetriades)

- Members of the Executive Committee are near retirement; IUGS looks for new enthusiastic members to take over the activities of the Commission!
- 2017: annual report from IUGS website
- IUGS Commission GGB sets the standards and the UNESCO International Centre on Global-Scale Geochemistry is obliged to follow.
- YES Network Congress in Tehran: a keynote lecture on global geochemical baselines mapping, and a two-day workshop was organised for young scientists in collaboration with the Geological Survey of Iran (August 2017)
- Workshop on Geochemical Mapping from Belt and Road countries in Langfang, China (September 2017) organised by the UNESCO International Centre on Global-Scale Geochemistry
- Sampling manual is in the writing stage, and the Blue Book will be revised
- RFG 2018 Vancouver Canada - organised session “RS24 global-scale geochemical mapping”, and at the request of the YES Network a two-day workshop is organised in collaboration with the Association of Applied Geochemists
- Establishing standards for global scale geochemical mapping and database development (Timo commented that we may need to revise the database standards)
- Collaboration with the Shenyang Geological Survey: mapping of black soil (BASGES)

12.15-12.30. Black Soil Survey BASGES (Alecos Demetriades, AD)

- The Chinese Black Global Soil Survey is a collaboration between the Shenyang Geological Survey and IUGS Commission on Global Geochemical Baselines and EGS, as well as other international organisations.
- Good funding
- Alecos represents the IUGS CGGB

- Manfred represents EGS GEG
- Vladimir Kos represents Ukraine
- Veronika Kopackova represents EGS Earth Observation and Geohazards Expert Group
- A workshop has been organised in China in December 2017.
- A presentation with recommendations was compiled by AD, David Smith, Patrice de Caritat and delivered by AD of how the survey should be performed.
- Everybody who wants to participate in this project should contact Manfred (or Alecos). The Shenyang Geological Survey (China Geological Survey) is paying for all expenses! In loess regions of Ukraine, Russia, Poland, Germany, Hungary, Czech Republic, Slovakia, Romania, Bulgaria, Moldavia, Austria and Serbia black soil are distributed. Countries who have black soils and want to participate are free to join the project!
- At the end a paper should be written how to protect the black soil from degradation.

12:30-14:00 Working Lunch

14:00-14.15. URGE status and JGE Special Issue (Alecos Demetriades, Manfred Birke)
- URGE I: a textbook was published in 2011
- URGE II: field sampling manual ready in 2015
- URGE II: brochure ready in 2016
- URGE I: JGE special issue April 2018; 13 papers + editorial
- URGE II: two reference standards are prepared by the Geological Survey of Slovakia, and more funding needed to continue.

14:15-14.40. Planned publications – status and new topics
- Ag, Au, PGEs (Alecos D.) – may shift ownership because Alecos is now already 3 years delayed (a summary paper will be prepared by end of August)
- Tl (Alecos D.) – shall be ready by the end of July
- Zr (Dee Flight & Clemens R.) – still interesting but other items have always been more important in addition to Dee moving into BGS management
- Br & I (Manfred Birke) – shall be ready this year
- FOREGS Perchlorate (Manfred B.) – shall be ready this year
- Mo (Dominico Cicchella) – in progress
- XRF/AR (Enrico Dinelli) – will be discussed in Italy – was almost ready already 2 years ago and is important!
- Another quality report (CNS, Iodine *etc.*) (Alecos D. is working on it)
- Magnetic measurements (K. Fabian)
- Zn (S. Albanese)
- Grain Size (Jasper G. ?)
- Colour (Klug & Fabian)
- Sr Isotopes (Jurian Hoogewerff, almost ready, promised for end of June)
- Element deficiency – (Koen Oorts)
- Medical geochemistry (Vibeke, Pat, Anna, Fiona)
- HTCEs (Li, W, Sb) (Philippe N.) – is in work
- New mapping techniques (Chaosheng)
- Spatial analysis of Cr (Gyozo J.)
- Spatial analysis of Hg (Gyozo J.)
- Spatial analysis - Selecting two major elements (Gyozo J.)
- Sn & W (Maria Battista active again)

14.50. Presentation by the new chair of the IUGS CGGB Public Relations and Finance Committee (Ariadne Argyraki)
- Data accessibility

- Networking
- Public engagement
- Fund raising
- Public impact
- Websites, social media
- Going outside IUGS countries
- Working groups
- Developing databases
- Various field manuals
- Twitter, Wikipedia, ResearchGate, Facebook, LinkedIn
- Can EGS update easily the EGS website?
- Who can deal with social media?
- Data for different target groups: forensic, exploration, medicine, environment
- Marketing of our data to increase the visibility urgently needed but will cost money and time

Ariadne's presentation generated a lively discussion, especially among the younger participants of the meeting, and several ideas will be tested.

15.15. GEMAS e-book (Manfred Birke)

- BGR has some financial problems and staff shortage, we need to choose between e-book or website, maybe ready by the end of this year.
- The GEG decided that an eBook on CD should not be prepared anymore. A decision about production of a GEMAS website by the BGR (Ms. Otremba) can only be taken after August 2018.
- Shall we have GEMAS data open? Do we need a permission from the publisher (probably not because the GEMAS book is 'owned' by BGR (for Manfred to investigate).

15:30-16:00 Working Coffee break

16.00-17.30. Presentations of recent or ongoing activities in the Surveys

16.00. Catalina Ramirez Mora	Geochemical Programme of Chile: advances and integration projects
16.25. Belinda Flem	Geochemical exploration in Norway
16.45. Clemens Reimann & Manfred Birke	Oppdal water survey
17.00. Timo Tarvainen	Applying FOREGS and GEMAS as background data in the AgriAs project
17.15. Anna Ladenberger	Till geochemistry in northern Norrbotten - regional trends and local signature in the key areas

17:30-18:30 - Guided visit to the Museum and Library of IGME

17th May Thursday

9.00-10.30. Presentations of recent or ongoing activities in the Surveys

9.00. Ivan Martin Mendez	Geochemical mapping and exploration with residual soils in central Spanish Pyrite Belt. Preliminary results
9.20. Paula Adanez	Geochemical Atlas of Spain as a WMS service

9.30. Javier Sanchez Espana	Geochemical research in flooded open pit mines: From characterization to remediation and modern mining
9.50. Jasper Griffioen	Quality Control of 11000 sediment samples
10.10. Fiona Fordyce	Soil and surface water geochemistry of the Clyde Basin, Scotland, UK

10:30-11:00 Working Coffee break

11.00-12-30. Presentations of recent or ongoing activities in the Surveys

11.00. Martin Soriano	The CSIRO experience on the application of infrared technology to the GEMAS data set: work performed, lessons learnt and future perspectives
11.30. Daniella Tolmács	History and future of geochemical mapping programmes in Hungary
11.45. Gevorg Tepanosyan	Development of Urban Geochemical Surveys in Armenia
12.00. Ariadne Argyraki	Surface soil geochemistry of the Olympias Basin, Kassandra mining district, Hellas
12.15. Gyozo Jordan *et al.*	Continental-scale spatial patterns emerging on geochemical maps. Identification and characterisation. Case studies for Cr and Hg

12:30-13:45 Working Lunch

13:45 - Presentations of recent or ongoing activities in the Surveys (4)

13.45. Stefano Albanese	A national-wide project to assess the distribution of toxic organic compounds in Italian soils. Materials, methods and some preliminary results
14.15. Mateja Gosar & Martin Gabersek	Urban Geochemistry: Soil and attic dust in the town of Maribor, Slovenia
14.30. Alecos Demetriades	Stream sediment geochemistry of Kastoria Lake basin and targets for follow-up exploration

All presentations will be made available through pCloud.

14.45 -15:15 - Research proposals

Discussion of possibilities to do some small but coordinated follow-up surveys on GEMAS (7-10 countries?):

- We should share proposals written in English in smaller groups
- We should use our network to work together, even in smaller groups
- Gyozo Jordan presented the SIMONA project (Sediment-quality Information, Monitoring and Assessment System) financed by INTERREG Danube Transnational Programme; 13 countries, Danube catchment project, Sediment Quality Monitoring, hazardous substances, water, soil sediment; GEG provides data and maps from FOREGS and GEMAS;
- One can copy the idea into the Baltic Basin – check INTERREG requirements; monitoring aspects.
- INTERREG funded a project in Ireland which got further funding from the Irish government
- We should standardise the protocols which we can use for various projects!
- Smart City projects – source of funding for urban geochemistry?

- Can we formulate template proposals which can be shared within the group and apply in regional settings?

15.15-15.30. - Survey of analytical facilities at the different Geological Surveys– our contribution to the Pillar 3 (Anna Ladenberger).

15:30-16:00 Working Coffee break

16:00-17:30 - Presentation of the New GEG Chair
Clemens Reimann resigns officially from his function of the GEG Chairman and Philippe Négrel takes over the leadership.

Anna Ladenberger and Philippe Négrel thanked Clemens Reimann on behalf of all GEG members for the excellent work he has done since 2006 for the GEG, and a photo-album was given to him of activities from 2006 to 2017.

The meeting continues with Philippe's short presentation about the future agenda, which can be summarised as follows:

- We need to establish a relationship with new EGS GS and new scientific secretary (visit of PN to Brussels)
- We need to establish contacts with DG Env, EEA and Eurometaux
- Collaboration with the JRC: new contract and 6 major topics for collaboration have been proposed
- Discussions with other expert groups
- Take a contact with the new Urban Geology group
- Contact marine expert group about the marine geochemistry proposals
- Laboratory facilities: EGS labs should collaborate, share equipment, the list has never been completed, and no feedback from EGS office; PGI has been leading this topic, BGRM took over (PN) but the mission has not been finished
- Next meeting is planned in Budapest in October 2019

Closure of meeting and farewell

18th May Friday
Geological excursion to the old Cu mining area (Otero de Herreros) and the historical town of Segovia.

19th May Saturday

The IUGS CGGB's mandate is to set up the standards on Global Geochemical Baselines mapping. For this purpose, a comprehensive field manual is in the process of writing, and the Blue Book will be revised. As it is important to demonstrate the sampling methods, their video filming was discussed by Alecos Demetriades with Alejandro Bel-Ian, and Juan Locutura offered to assist as well. Therefore, a field trip was organised by Alejandro, who has expertise on video-filming.

08:00:- Setting off from the IGME headquarters. The team members were: Alecos Demetriades (IUGS-CGGB), Alejandro Bel-lan (IGME), Iván Martín (IGME), Juan Locutura (IGME retired/member of the first WEGS group), and J. Mariano Martínez (IGME driver/field assistant).

09:30:- Video filming of overbank sediment sampling protocol on the left bank of Manzanares River. Coordinates N 40º 19.351' W 3º 33.458' (Fig. A1.1). A river that was used in the WEGS Pilot project.

Figure A1.1. Overbank sediment sampling site on the left bank of Manzanares River, Spain (Photo: Alejandro Bel-Ian).

12:00:- Video filming of the stream sediment sampling protocol at Gargüera stream, a tributary of Guadalix river. Coordinates N 40º 47.668' W 3º 40.004' (Fig. A1.2). This is one of the field training sites of IGME.

Figure A1.2. Stream sediment sampling site, Gargüera stream, a tributary of Guadalix River, Spain (Photo: Alejandro Bel-Ian).

APPENDIX 2: FIELD-TRAINING COURSE, RFG2018, VANCOUVER

A2.1. OVERBANK OR FLOODPLAIN SEDIMENT SAMPLING

Compiled by Alecos Demetriades and Patrice de Caritat
IUGS Commission on Global Geochemical Baselines

Overbank or floodplain sediments are deposited in layers during flood events in a low energy environment on the floodplain and levees (Ottesen *et al.*, 1989, 2010; Alexander and Marriott, 1999). They are completely devoid of gravel and coarse-grained sand, which indicate a high- and medium-energy environments, respectively. Since floods are recurring events in the geomorphological history of a drainage basin, a succession of almost horizontal layers is built-up. Consequently, a vertical section through overbank sediment layers reflects the history of sedimentation back in time (Fig. A2.1). Due to channel shifting, in addition to the fine-grained (silty-clay, clayey-silt) sediment layers, there may be in the vertical section gravelly and sandy layers, representing the bottom channel load of high- to medium-energy environments, respectively.

(a) (b)

Figure A2.1. Overbank or floodplain sediment sections: (a) comparatively recent unconsolidated overbank sediment sequence, Euboea Island, Hellas; (b) older indurated overbank sediment sequence; note the channel shift from low-energy environment at the bottom with four fine-grained sediment layers, then a high-energy environment with variable size bottom load pebbles and sand (central part), and at the top again a low energy environment with two recognisable fine-grained floodplain sediment layers, Lavreotiki peninsula, Hellas (from Demetriades, 2014, Photo 4, p.13).

During flood events, heavy rainfall and the resulting large quantity of water in the drainage basin increase the erosive capability of a stream, thus activating many sediment sources. Consequently, a composite overbank sediment sample, comprising many layers, is representative of a large part, or even the whole, of the upstream drainage basin (Ottesen *et al.*, 1989, 2010; Bølviken *et al.*, 1996). In some cases, the sedimentation history may be complex due to erosion of former overbank sediment deposits, and their subsequent deposition further downstream. Therefore, younger overbank sediments, deposited downstream may then be intermixed with material from older overbank sediment layers. This action does not reduce, however, the representativeness of overbank sediment because the reworked sediment still represents material from the upstream drainage basin.

Surficial overbank sediments are normally affected by recent anthropogenic activities and, thus, may be contaminated (Fig. A2.2). Deeper overbank layers, if deep enough, should normally be pristine and, therefore, depict the natural geochemical background variation of the upstream drainage basin (Bølviken *et al.*, 1990, 1993, 1996; Demetriades *et al.*, 1990, 1993, 1994; De Vos, Tarvainen *et al.*, 1996; Hindel *et al.*, 1996; Ottesen *et al.*, 2000).

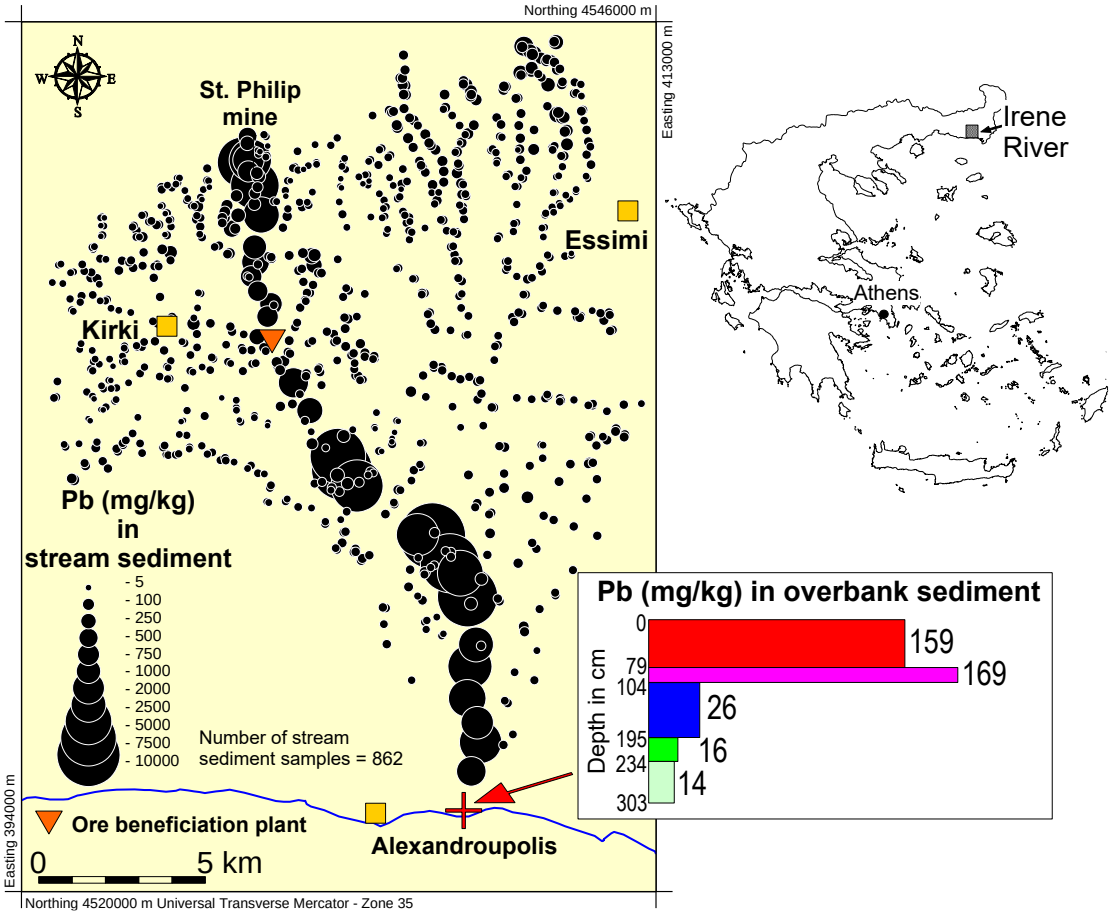


Figure A2.2. Distribution of Pb in the <0.180 mm reconnaissance stream sediment fraction, and in the <0.063 mm fraction of overbank sediment layers, Irene River, Thrace, N.E. Hellas. Note (a) the contamination train from the St. Philip mine and ore beneficiation plant, and (b) the two surface layers of overbank sediment that show contamination, and the lower layers tending towards background conditions (from Demetriades, 2014, Fig. 8, p14).

Prior to sampling, the exposed overbank sediment sequence is first studied carefully to select a suitable section with many layers of fine-grained material (silty-clay or clayey silt), with the objective to reach, at depth, pristine sediments. According to Ottesen *et al.* (2010), overbank sediment sample locations may be classified into three categories, according to river channel type:

(i) In meandering or straight stream segments, the natural levee or slack water parts of the river floodplain may provide sampling sites for both recent and pristine or pre-industrial overbank sediment samples.
(ii) In braided rivers, the overbank sediment layer is generally thin and spreads out over large areas. Ages of braids vary across the channel. In such cases, sufficient knowledge of the sedimentation history is required to be able to distinguish between pristine and contaminated overbank sediments.
(iii) If river terraces occur, their relative stratigraphic ages have to be determined in order to identify suitable sites for collecting older and younger overbank sediment samples.

Overbank sediment sampling sites are selected at the lowermost points of floodplains of second, third and fourth order streams. Sites adjacent to roads, railway lines or ditches (minimum distance 10 m) should be avoided.

There are two variants of overbank sediment sampling, depending on project objectives, *i.e.*, (i) channel sampling of all layers resulting in a composite sample, and (ii) sampling of surface (top) and lowermost (bottom) layer. In both cases, a section is either cut in the exposed overbank sediment sequence or a deep enough pit is dug in the floodplain. Living surface vegetation, and large roots are removed before taking the composite or top overbank sediment sample.

A2.1.1. Global Geochemical Baselines project

In systematic top and bottom floodplain or overbank sediment sampling, the sampling scheme used in the global geochemical baselines project, 25-cm thick sections are sampled from single layers only (Salminen, Tarvainen *et al.*, 1998; Salminen *et al.*, 2005b). If the layer is less than 25 cm, then the actual thickness is recorded on the field observation sheet. Always, sample first the bottom floodplain or overbank sediment, and then the top layer; the reason for this procedure is that if the top layer is sampled first, material will fall at the bottom of the section, thus covering the exposed bottom layer, and the bottom part will have to be exposed again.

Sample weight depends on the grain-size for analysis. If the natural <2 mm sediment fraction is to be analysed, then a weight of 1 kg is sufficient. However, for the global geochemical baselines project a 2 kg sample weight is recommended, as it is required to have a sufficient amount of <2 mm archive sample for future reference.

A2.1.2. Terminology

Darnley *et al.* (1995, p.30) have made an arbitrary distinction between overbank and floodplain sediment.

Overbank sediment is the fine-grained sediment deposited on the floodplain of small rivers, which are tributaries to a larger river (Fig. A2.3).

Floodplain sediment is the fine-grained sediment deposited on the floodplain of large rivers, and usually have their outlet to the sea or a lake (Fig. A2.3).

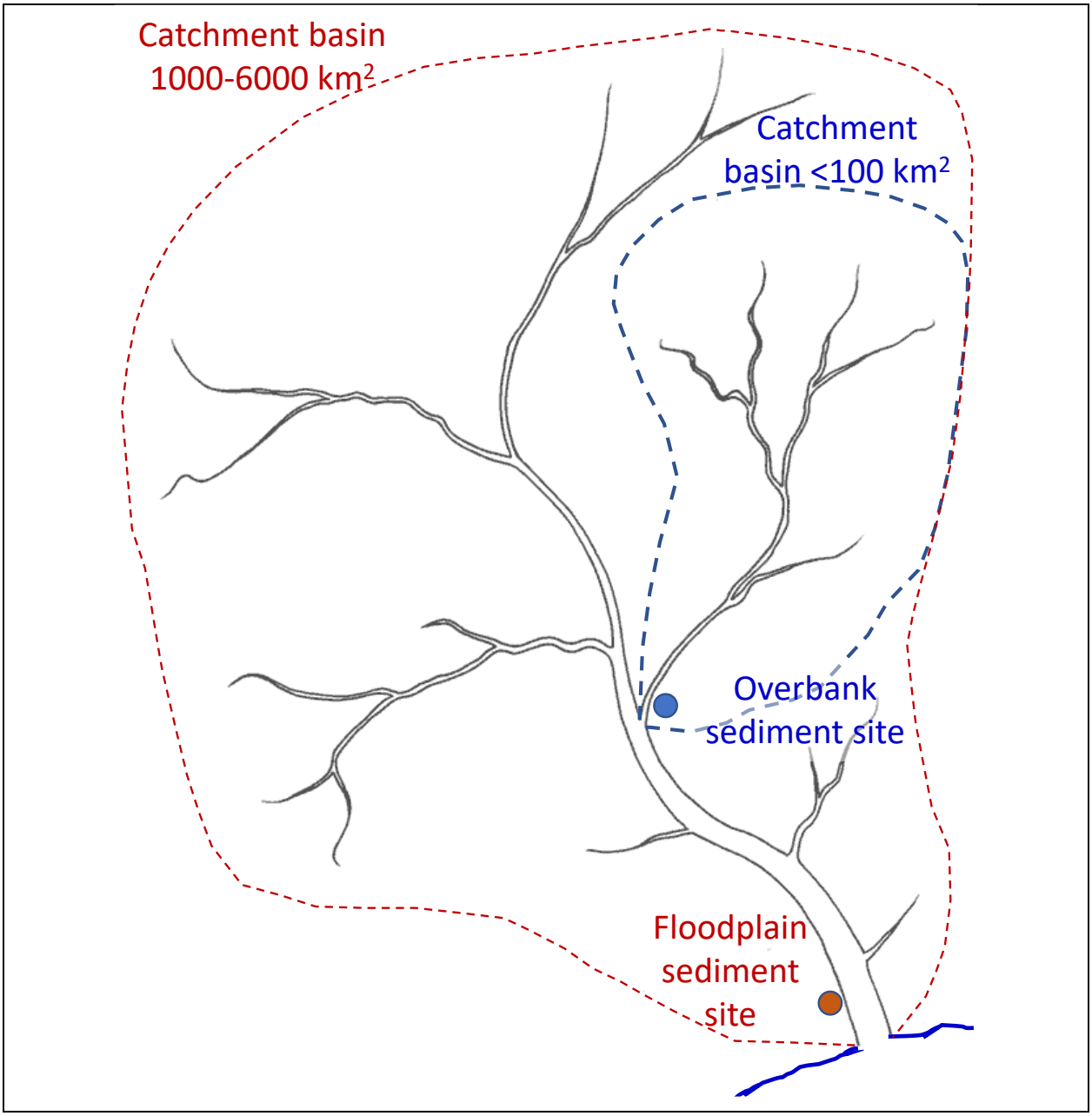


Figure A2.3. Schematic diagram of a drainage basin showing the floodplain and overbank sediment sites from which the corresponding samples are collected from the main 3rd and 2nd order streams, respectively. It is noted that from the small 2nd order drainage basin, apart from overbank sediment, other sample types are collected, such as stream sediment, stream water, residual soil and humus,

A2.1.3. Global Geochemical Baselines Sampling Scheme

Figure A2.4 shows the Global Terrestrial Network (GTN) random sampling scheme within the 160 x 160 km grid cell N43E09, which is situated in Finland.

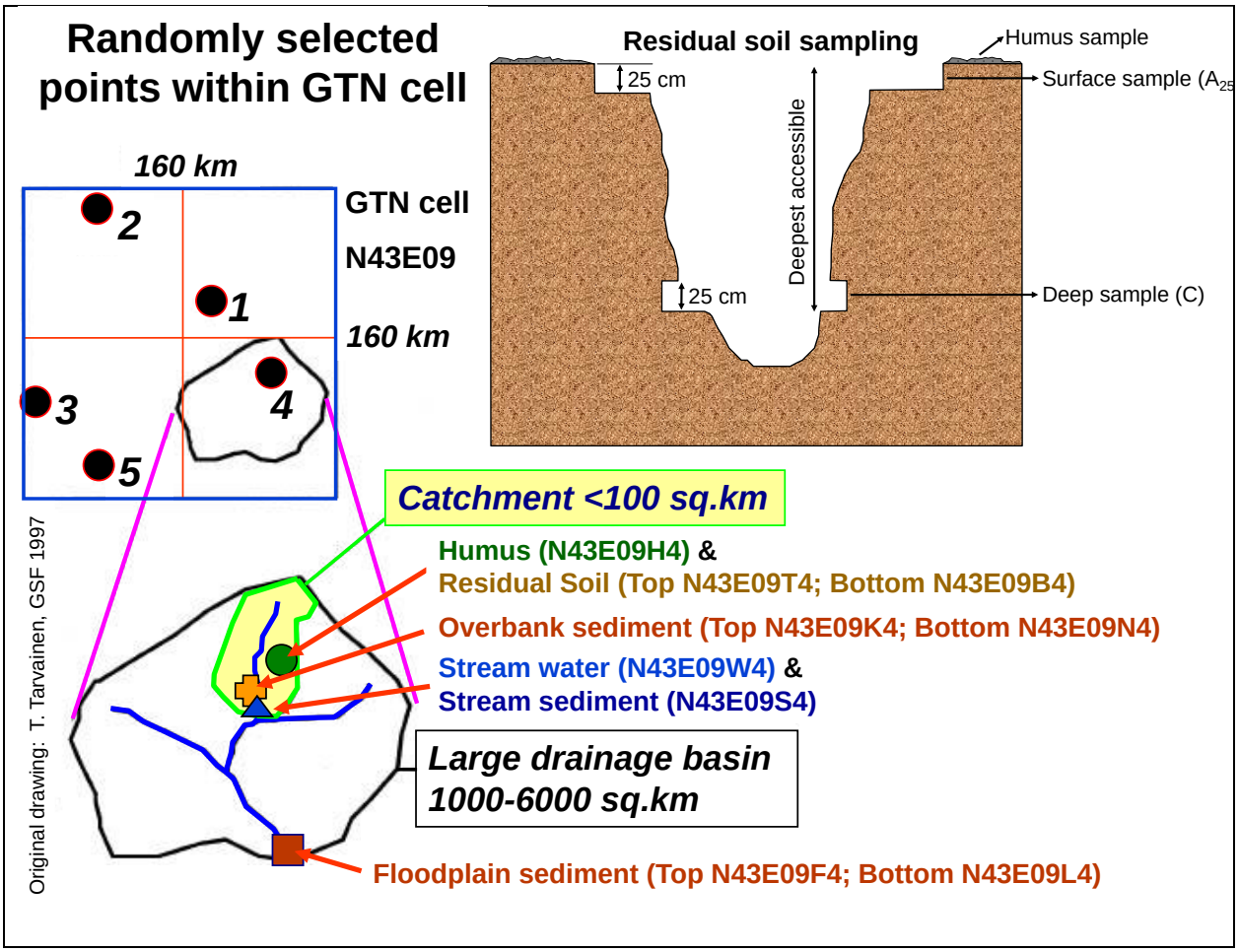


Figure A2.4. Selection of sampling sites (modified from Darnley et al., 1995, Fig. 4-4, p.42, and Salminen, Tarvainen et al., 1998, Fig. 3, p.13). Schematic outline of sampling pattern and soil sampling pit for geochemical reference network (GRN). The sample pit applies to all residual soil locations. Deep soil sample (C): a 25-cm thick section within a depth range of 50 to 200 cm, and always from the same horizon.

A2.2. RFG2018 YES NETWORK FIELD COURSE

A2.2.1. Floodplain sediment sampling

The two drainage basins selected for the YES Network field training course, Squamish River and Britannia Creek, are situated in GRN grid cell N34W58 (Fig. A2.5). Because of the high relief, Britannia Creek is a fast- flowing stream, and has not developed an alluvial floodplain. Due to the mountainous terrain it was not possible to find also a suitable site for sampling residual soil that can be accessed easily by road. Active stream sediment and stream water could be sampled, as well as colluvium, heavy mineral concentrates and moss mat sediment, sample media used in mineral exploration.

Squamish River was visited and suitable sampling sites for sampling floodplain sediment were found to the north of the Dentville settlement, they were, however, inaccessible for a large group of people. Hence, a compromised solution was selected, just for demonstration of the sampling procedure. The floodplain sediment site is situated between the settlements of Squamish and Dentville (Fig. A2.6), and is next to the truck road (easily accessible by coach),

and the railway line (Fig. A2.7). The sample site is on the bank of an ox-bow branch of Squamish River, which is inundated during high tide, a fact that makes it unsuitable for sampling, because of the marine influence. The requirements for an acceptable floodplain sediment site are: it should be upstream from settlements, bridges, main roads, and not affected by high tide.

Figure A2.5. Google Earth image of the Geochemical Terrestrial Network or Global Terrestrial Network (GTN) grid cells of 160 x 160 km covering Canada.

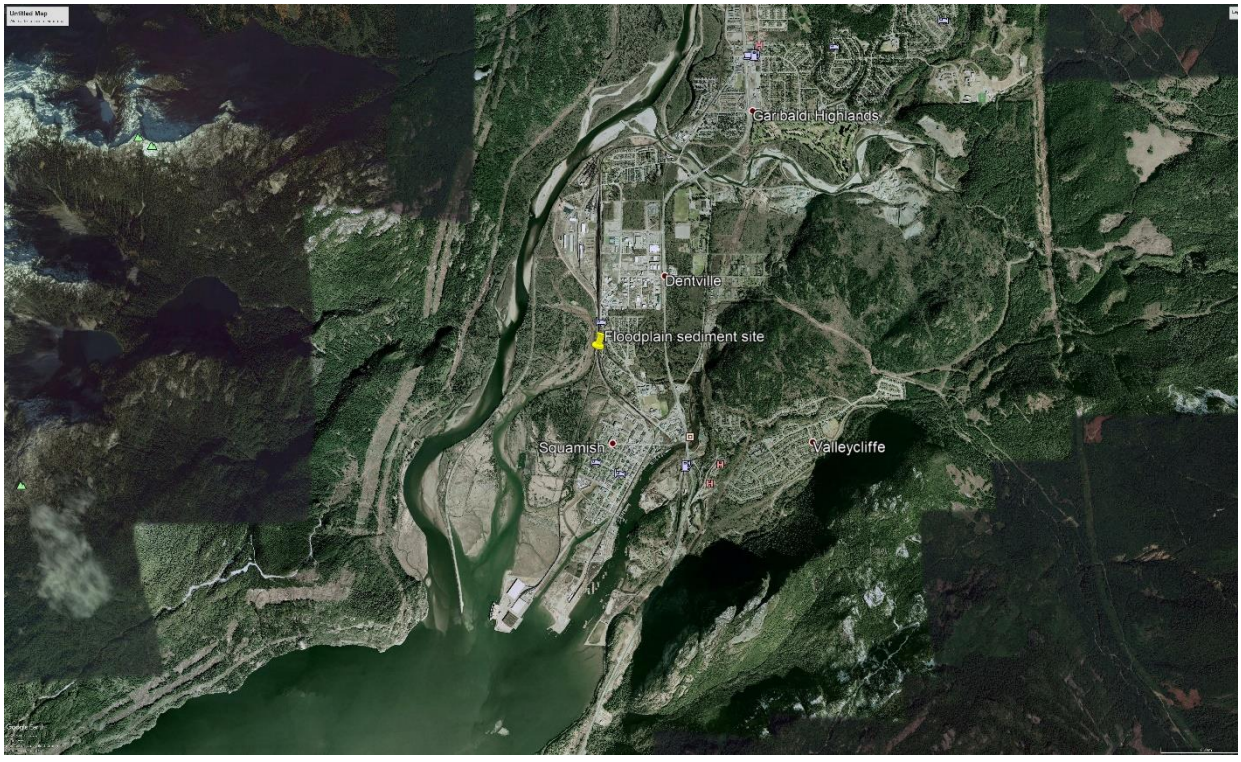


Figure A2.6. Google Earth image of floodplain sediment sampling site N34W58F1/L1 between the settlements of Squamish and Dentville, British Columbia, Canada.

Figure A2.7. Google Earth image of floodplain sediment sampling site N34W58F1/L1 on the bank of an ox-bow branch of Squamish River, British Columbia, Canada.

A better sampling site was observed on the opposite side of the ox-bow branch, where recent and older sediments were observed (Figs. A2.8 & A2.9). If the opposite side could be reached, again it would have been just for demonstration of the sampling technique. Figure A2.10 shows the characteristics of the floodplain sediment site from where the samples were collected.

Figure A2.8. Google Earth image of floodplain sediments on the left-hand side bank (opposite the sampling site N34W58F1/L1), Squamish River, British Columbia, Canada.

Figure A2.9. Floodplain sediment on the opposite bank of the demonstration sampling site N34W58F1/L1, Squamish River, British Columbia, Canada.

(a)

(b)

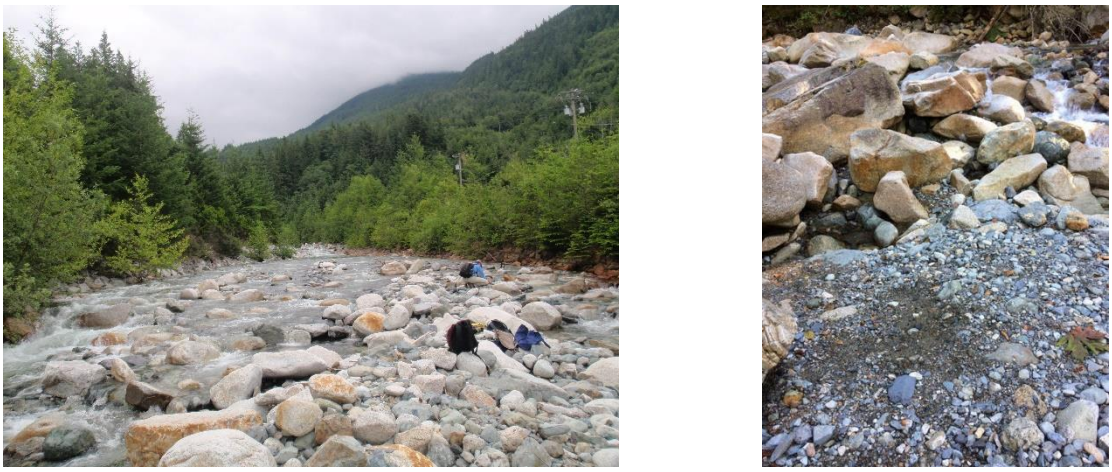
(c)

(d)

Figure A2.10. Floodplain sediment sample site, Squamish River, British Columbia, Canada: (a) Sample number; (b) Landscape photograph; (c) Top and bottom samples with sample number over the infill pit, and (d) floodplain sediment section: top and bottom silty-clay samples were collected from 0-8 cm, and from 28 to 33 cm, respectively. Another two floodplain sediment layers occur from 8-20 cm and 20-28 cm.

A2.2.2. Stream sediment and heavy minerals concentrates sampling

Sampling of active stream sediment (Fig. A2.11) and heavy minerals concentrates (Fig. A2.12) was demonstrated by John Gravel on Britannia Creek.



(a) (b)

Figure A2.11. Britannia Creek in British Columbia (Canada) is a high energy stream from its upper to lower reaches as indicated by the large boulders (a). As it would have taken considerable time to sieve the stream sediment on site, John Gravel has collected a bulk sample from several points for sieving in the lab (b).

(a) (b)

Figure A2.12. Gold pan with sediment for panning for heavy mineral concentrates (a); Patrice de Caritat (sitting) and John Gravel (standing) examining the heavy mineral concentrates, Britannia Creek, British Colombia.

For description of stream sediment sampling procedure refer to p.19 to 21 of the FOREGS Geochemical Mapping Field Manual (Salminen, Tarvainen *et al.*, 1998).

A2.2.3. Stream water sampling

Stream water sampling was demonstrated by Ray Lett (Fig. A2.13).

Again, for description of stream water sampling procedure refer to p.16 to 19 of the FOREGS Geochemical Mapping Field Manual (Salminen, Tarvainen *et al.*, 1998).

(a) (b)

(c) (d)

(e)

Figure A2.13. (a) Ray Lett writing the stream water sample number on the bottles, one for unfiltered stream and another for filtered water; (b) Collecting stream water; (c) Decanting the stream water into a beaker; (d) Drawing the stream water with a syringe, and afterwards adding the 0.45 μm filter, and (e) Injecting the filtered water into plastic bottle.

A2.2.4. Seaweed sampling

Seaweed sampling for assessing marine water contamination from the mining activities in Britannia Creek was demonstrated by Colin Dunn (Fig. A2.14)

(a)

(b)

(c)

Fig. A2.14. (a) Seaweed sampling site is from the rocks in the upper right hand corner of the photograph; (b) Colin Dunn holding the seaweed sample, and (c) Close-up of seaweed sample.

For information about the use of seaweed as an exploration medium but also for recording contamination two articles in the Newsletter for the Association of Applied Geochemists "*Explore*" should be consulted:

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Dunn, C. & McCaffrey, R., 2018. *Seaweed as an Exploration Medium along the inlets of British Columbia – Part 2: Chemical variations and long-term changes – Howe Sound*. Explore 178, 1 & 5-7 & 8-12; https://www.appliedgeochemists.org/sites/default/files/documents/Explore%20issues/Explore%20Number%20178%20March%202018.pdf.

A2.3. ACKNOWLEDGEMENTS

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APPENDIX 3: REGIONAL REPORTS

A3.1. AFRICA

Report by Theophilus C. Davies (Dept. of Geology, University of Nigeria, Nsukka, Nigeria)

A3.1.1. Introduction

In 2018, large-scale geochemical sampling and analyses within the ambit of the '*Africa Geochemical Database (AGD) Project*' were again, rather limited. However, at least three major on-going mapping programmes in three countries of the Continent incorporate significant geochemical survey components that are potentially usable in an eventual compilation of a complete geochemical map of Africa. A number of preparatory meetings - both formal and informal- discussed plans for strengthening, with matching funds, a well-structured geochemical database programme that would elicit wide participation from geological surveys and other relevant geoscientific institutions around the Continent.

A brief status report on progress of the AGD Project was presented by the Nigerian Geological Survey Agency (NGSA) at the Mid-Term Meeting of the PanAfGeo Project jointly organised by the French Geological Survey (BRGM) and the Organisation of African Geological Surveys (OAGS) in Dakar, Senegal, during 10-11 May, 2018 (The PanAfGeo M18 Mid-term meeting, 2018; Isaac Okorie, pers. comm., 2018). The Report stressed the importance and urgent need for increased efforts in revitalising the AGD Project. The purpose of the PanAfGeo Meeting was to serve as a forum for enhancing the human capacity building of African Geological Surveys (GSOs). The meeting deliberated on progress that has been achieved by the Project in human capacity building of Geological Surveys in Africa.

A3.1.2. On-going programmes of some relevance to the Africa Geochemical Database Mapping project

A3.1.2.1. PanAfGeo project (European Commission financed project managed by EuroGeoSurveys)

The BRGM (the French Geological Survey) introduced three new programmes in 2017, on '*Geological Mapping and Mineral Inventories*' in Chad, Malawi and Cameroon, respectively (BRGM, 2017). The common aim of these programmes is to support economic development in Africa by updating knowledge on its geology and mineral resources; and would incorporate a significant regional geochemical mapping component.

Chad: The project in Chad would include a study of archived materials and interpretation of satellite imagery to prepare for reconnaissance on the ground, airborne geophysical surveys and field sampling. The data retrieved will be incorporated into a geology and mining information system and used to produce maps to the scale of 1:200,000. A major training component, based on mentoring, will involve the Chadian geologists in all of the project phases.

Malawi: The Malawi project, '*Geological Mapping and Mineral Assessment of Malawi*' (GEMMAP), comprises a geological mapping and mineral inventory programme across the entire Malawian territory.

In particular, the project will update the geological map coverage of the country (40 maps to the scale of 1:100,000; 10 maps to 1:250,000 and one to 1:1,000,000), and produce an inventory of its mineral potential; and will also include a survey of stream sediment geochemistry, a natural risk mapping campaign, an analysis of the small-scale mining sector, and production of a database and Geographic Information System. Also incorporated in the programme is a training component for Malawian geologists, which will be provided through both field courses and diploma courses (Master's and Ph.D.).

Cameroon: A geological and geochemistry mapping programme, which includes the production of a Geological and Mining Information System, originally launched in 2016 focuses on three main project components in central Cameroon:

- Production of 13 geological maps to the scale of 1:200,000;
- Mineral exploration across the entire area with some 18,000 samples to be taken;
- Development of a Geological and Mining Information System to distribute the information gathered and promote Cameroon's mining sector.

This Project would also include a training and skills transfer component which will benefit Cameroon's scientific and institutional players.

A3.1.2.2. Royal Society programme

The Project "Strengthening African Capacity in Soil Geochemistry to Inform Agriculture and Health Policies" is funded by the Royal Society, Department for International Development (RS-DFID) Africa Capacity Building Initiative. Round 1 runs from 2015 - 2020.

In order to understand soil geochemical processes and how this understanding can be used to support policies in agriculture and public health, and increase knowledge, and strengthen capacity in soil geochemistry, extensive geochemical sampling and analyses are planned in Malawi, Zambia and Zimbabwe. A cross-disciplinary doctoral training network would encompass analytical chemistry, geospatial integration and analyses, and soil management and key vocational skills.

A3.1.2.3. Outreach programme of Geochemical Society and European Association of Geochemistry

The Geochemical Society (GS) and the European Association of Geochemistry (EAG) Outreach Programme for Africa is a partnership between the two institutions with the objective of developing outreach activities in geochemistry in under-represented regions of the world (the Geochemical Society, 2018).

As part of the 2018 Outreach Program to Africa, the '*Africa Initiative for Planetary and Space Sciences*', identified its objectives as, to:

- Connect African Planetary and Space Scientists with their international peers;
- Build a road map for Planetary and Space Sciences in Africa by identifying key research areas where African scientists can make significant contributions;
- Solicit sponsors to support the development of this research domain in Africa, and
- Contribute to sustainable development in Africa through research, education, and public outreach in Planetary and Space sciences.

A3.1.3. Meetings, conferences and workshops relevant to the Africa Geochemical Database effort

1. The UNESCO International Centre for Global Scale Geochemical Mapping (ICGG)

An International Workshop to review progress in geochemical mapping within the scope of the International Scientific Cooperation Programme: '*Mapping the Chemical Earth*' was held at the UNESCO-ICGG in Langfang, China from 14-17 October, 2018. Eight members of the Nigerian Geological Survey Agency were among the participants from Africa.

The Second Session of the Governing Board and Scientific Committee Meeting of the UNESCO-ICGG was convened on the 16th and 17th of October, 2018. A major agenda item at this Meeting was a review of sampling and laboratory analyses protocols for the Global Geochemical Baselines, especially with regard to the recommended sample type for collection under different physiographic settings. The '*Africa GEO-2017-2019 Work Programme*' that was

suggested in the GEO Group on EARTH Observations Proposal (Activity ID 77) (Group on Earth Observation, 2016), recommended the collection of:

- Overbank sediment in mountainous and hilly terrains; and
- Floodplain or catchment basin sediment in desert, savannah and plain terrains.

The ICGG re-iterated its commitment to increased effort in intensifying the 'Mapping Chemical Earth Program in Africa' in the coming years.

2. The Sino-Nigeria Geochemical Mapping Project Takes Off

The Federal Government of Nigeria flagged off the next phase of implementation of '*Low Density Geochemical Mapping Project*' developed between the China Geological Survey (CGS) and the Nigerian Geological Survey Agency (NGSA) through a Memorandum of Understanding on Bilateral Geoscience Cooperation signed by the two countries on November 23, 2016. Seven scientists from the China Geological Survey visited Nigeria on 20 September, 2018 to commence the process of implementation of the '*Low Density Geochemical Mapping Project*' in accord with the agreement on upgrading the '*National Geo-information System*' and improving the geo-data sharing agenda of Nigeria.

According to Dr. Alex Nwegbu, Director-General of the NGSA, the Project will include training of staff in geochemical mapping, and a capacity building programme designed to enhance the competence of professionals in the field of mining in Nigeria. At this meeting, the importance of having complete geochemical maps for Nigeria was reiterated, as this, according to Dr. Nwegbu, would have considerable applications in resource exploration, as well as in addressing issues relating to the environment and health.

The Nigerian Geochemical Mapping Project (2008 - 2011) was a national programme of geochemical mapping funded by the World Bank through the Nigerian Sustainable Management of Mineral Resources Project (SMMRP) to give technical assistance to the NGSA to carry out a national programme of geochemical mapping.

The Global Reference Network (GRN) of cells used for regional geochemical mapping has 44 cells in Nigeria. The Project completed the equivalent of two of these cells (the Minna and SW cells, respectively) to demonstrate to the NGSA how regional geochemical mapping should be conducted. The results were presented in a series of geochemical maps.

The team leader of the Chinese delegation, Dr. Yao Wensheng, in his presentation, expressed appreciation to the leaders of the two countries for the promotion and establishment of the project, saying the commencement of the project was a good start for cooperation in the field of geosciences, and that the two countries will achieve a lot with the effort of the two leaders.

3. ICAM 2018: The 20th International Conference on Applied Mineralogy and Geochemistry, Cape Town, South Africa, 15 - 16 November, 2018

(https://waset.org/conference/2018/11/cape-town/ICAMG) (accessed 30.11.2018)

ICAMG 2018, the 20th International Conference on Applied Mineralogy and Geochemistry brought together leading academic scientists, researchers and scholars, who exchanged and shared their experiences and research results on all aspects of Applied Mineralogy and Geochemistry. The Conference also provided a premier interdisciplinary platform for researchers, practitioners and educators to present and discuss the most recent innovations, trends, and concerns, as well as practical challenges encountered and solutions adopted in the fields of Applied Mineralogy and Geochemistry.

4. 34th SEGH International Conference on Geochemistry for Sustainable Development, Avani, Victoria Falls Resort, Livingstone, Zambia, 02 - 07 July, 2018

An engaging and varied programme at this Conference comprised 45 oral presentations and 46 poster presentations by delegates from all over the world, and dealt with the following themes:

(i) Industrial and Urban Development;
(ii) Agriculture;
(iii) Health;
(iv) Technologies.

5. IMGA Nigeria Chapter - Inaugural Conference with the theme: "The Nexus Between Geology Environment and Health" took place at the Geology Department, University of Ibadan from 12 - 14 December, 2018.

Highlight of this Meeting was the presentation by Prof. T.C. Davies of the 'advocacy paper': '*Medical Geology Applications of an Africa Geochemical Database*', a presentation that was first delivered at the official inauguration of the UNESCO International Centre on Global-Scale Geochemistry at the IGGE in Langfang, China in May, 2016 (http://en.cags.ac.cn/News/10324.htm (accessed 15.12.2018)).

A snapshot of this presentation to an audience, which, thankfully, included Nigerian government representatives, including from the NGSA, and other national policy formulators, who apparently, finally, imbibed the message, is given below.

"The significance of a complete, high quality Africa Geochemical Database (AGD) for addressing the range of Earth and environmental science issues (*e.g.*, mineral exploration, resource evaluation, agriculture, land use planning, processes of crustal evolution, modelling of environmental systems), cannot be over-emphasised; because, for such applications to be made in a robust fashion, we need to understand how the Region's unique and complex geochemical landscape was carved out in the first place. The distinctive nature of Earth processes, such as intense tropical weathering, leaching, erosion, podsolisation and gleying, as well as later imprints of urbanisation and industrialisation, have engendered the mobilisation and clear redistribution of all but the most refractory elements.

As a consequence, it is not uncommon to find large tracts of the Continent's surface environment containing anomalous trace element contents or deficiencies in essential micro-nutrient elements. Through water and food crops, extremes in trace element variation in soils are transmitted into the food chain, with often undesirable consequences for human and animal health. It is thus considered that one of the most important applications of an AGD would be in understanding the hydrological, chemical and biological processes that determine the behaviour of nutritional and toxic elements in the surface environment, in relation to how they may affect the health of man and animals (Medical Geology). This is so, because most of Africa's population still lives close to the land, and depends on it for their daily sustenance.

Important scientific problems that would confront the construction of an AGD include, defining and understanding 'regional background', and the evolution of appropriate sampling and analytical protocols that would consider the Regions' unique and complex element distribution patterns in the surficial geochemical environment. These problems are apparently intractable, but are not unsolvable.

Longstanding operational and logistical problems that have impeded previous (largely uncoordinated) efforts at an AGD compilation include the limited availability of state-of-the art analytical instrumentation, and requisite laboratory infrastructure. An even more important limitation is the dearth of a sufficient number of highly skilled analytical geochemists and other

technical personnel located at appropriate regional centres, able to install, operate, trouble-shoot and maintain modern analytical equipment. These problems are compounded by the lack, up to now, of adequate international funding to undertake such a high precision and systematic mapping exercise.

In this presentation, recommendations were put forward for carrying out a successful and complete compilation of a high quality AGD that would be invaluable for studies in Medical Geology, as well as in an array of other multipurpose, multi-national environmental applications; and proposed measures given for counteracting potential limitations in its development."

A3.1.4. Synthesis

Reasons given for the low scientific output: geochemical sampling, laboratory analyses, data processing and data portrayal.

Reasons advanced for the low rate of progress of the Africa Geochemical Database Programme are:

1. Lack of adequate funding. See, *e.g.*, Section 9 of the IUGS Commission on Global Geochemical Baselines Annual Report for 2017 (http://www.globalgeochemicalbaselines.eu/datafiles/file/IUGS_CGGB_Annual_Report_2017_Final_Web.pdf (accessed 10.12.2018)).
2. Lack of communication and strong advocacy among African Geological Surveys and relevant national institutions.
3. Lack of expertise to carry out geochemical surveys (Insufficient number of Training Workshops) held, and inadequacies in the curriculum content. Many geochemical laboratories in Africa still suffer technical/analytical capacity constraints.
4. Lack of conviction by African Governments about the usefulness of the programme (especially with regard to resource exploration), given that the originally recommended sampling density is apparently so low (1 sample per 4,000 km^2).

A3.1.5. How useful would such a low-sampling density geochemical map be for African countries?

One of the factors militating against investment by African Geological Surveys (Governments) in the Africa Geochemical Database Project, is the question of "*How useful would such low-sampling density geochemical mapping*" be, in particular, for mineral exploration purposes, which is the envisaged primary purpose for such an apparently huge financial outlay by African Governments with high mineral resource potential in their jurisdictions' cadastral systems.

This question has been well addressed in a 2016 paper by Reimann *et al.* (couched on the mineral system concept), who conclude on p.48 that "… *low density geochemical mapping holds great promise in the early stages of mineral exploration programmes in guiding subsequent effort into the more fertile regions. Interpretation of these maps, however, may need a different approach than that used in classical, high density mapping exercises, where only 'high values' of certain metals are the traditional target*". An earlier paper by Smith and Reimann (2008) also showed convincingly how useful (how robust) such a sampling programme can be, and how relationships to processes such as climate and weathering acting at the broad scale of mapping can be drawn. These authors went on to conclude that low-sampling density geochemical mapping can provide a viable means of determining the abundance and spatial distribution of elements in the near-surface environment of the Earth at continental and global scales.

Ironically, it was in Africa that the usefulness of such low-sampling density programmes (1 site per 200 km^2) were first demonstrated. Low-sampling density geochemical surveys conducted during the late 1960s and early 1970s include those in Sierra Leone by Garrett and Nichol (1967) and in Zambia by Armour-Brown and Nichol (1970).

A3.1.6. References cited, and other pertinent 2017/2018 bibliography

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A3.2. AMERICA, NORTH

Report by David B. Smith (United States Geological Survey)

Continued work on the North American Soil Geochemical Landscapes project resulted in the writing of the following paper:

Grunsky, E.C., Drew, L.J., Smith, D.B., 2018. ***Analysis of the United States portion of the North American Soil Geochemical Landscapes project – A compositional framework approach***. Chapter 17 In: Daya Sagar, B.S., Cheng, Q. & Agterberg, F. (Editors), Handbook of Mathematical Geosciences, Springer, Cham, 313-346; https://doi.org/10.1007/978-3-319-78999-6_17.

A3.3. AMERICA, SOUTH

A3.3.1. Chile

Report by Juan Pablo Lacassie Reyes (Unit of Geochemistry, Geological and Mining Survey of Chile)

A3.3.1.1. 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 growing of Chile by: (i) The definition of geochemical baselines, and (ii) The identification of mineral resources.

From 2011-2018 the Government of Chile has provided funding of approximately US $ 4,000,000 for fieldwork, sampling, sample preparation, chemical analyses and staff salaries.

A3.3.1.2. Main achievements during 2017-2018

During 2017-2018 the main activities and results of the Geochemical Unit were as follows:

(i) Geochemical Databases at 1:250.000 scale (Map Sheets):

- *Vallenar Sheet:* Published;
- *Copiapó Sheet:* In edition;
- *El Salvador Sheet:* In edition, and
- *Taltal Sheet:* Geochemical sampling completed (100%).

(ii) Technical Reports in Geochemistry:

- *IR-16-61*: Geochemical study of ore deposits of the Atacama Region, Northern Chile (URL: http://tienda.sernageomin.cl/tiendavirtual2/ProductDetail.aspx?pid=2755);
- *Huasco River Fluvial System*: Geochemical and Mineralogical study (In Prep);
- *Copiapó River Fluvial System*: Geochemical and Mineralogical study (In Prep), and
- *El Salado River Fluvial System*: Geochemical and Mineralogical study (In Prep).

(iii) International Cooperation Projects/Agreements:

- ***Guyana Project***: A cooperation project between the Geological Surveys of Chile and Guyana has been implemented between 2017 and 2018. Four missions (2 in Guyana and 2 in Chile) have been accomplished for training and sharing of experience in geochemistry and economic geology (Fig. A3.3.1).

- ***SERNAGEOMIN-ICGG***: During 2018 a Memorandum of Understanding was signed between the Geological Survey of Chile (SERNAGEOMIN) and the UNESCO

International Centre on Global-Scale Geochemistry (ICGG), as a first step to implement in Chile the Global Geochemical Baselines project.

(iv) National Cooperation Agreements:

- ***Geochemical Monitoring of Valdivia River***: During 2018, a cooperation agreement between the Geological Surveys of Chile and the Ministry of Environment of Chile (MMA) has been implemented. From 2018 onwards, the Geochemical Unit of SERNAGEOMIN, will take part in an environmental monitoring programme of the Valdivia River Fluvial System (southern Chile). This is the first time in Chile that the geochemical information of fluvial sediments is officially included for environmental monitoring of a fluvial system. The agreement involves the analysis of geochemical information of fluvial sediments, collected from 10 sampling points of the Valdivia River Basin. The sediments are periodically sampled (summer and winter) and the geochemical information is analysed for year/season variations. A report will be submitted, each year to the Ministry of Environment of Chile (MMA).

(v) Other activities:

- ***IUGS-CGGB Meeting***: One member of the Geochemical Unit, Mrs. Catalina Ramírez, took part in the joint meeting of the IUGS Commission on Global Geochemical Baselines and EuroGeoSurveys Geochemistry Expert Group, which was held in Madrid (Spain) during May of 2018 (see Appendix 1).

- ***1st Latin American Geochemical Congress***: Two members of the Geochemical Unit, Mr. Felipe Astudillo and Mr. Juan Pablo Lacassie, took part in the 1st Latin American Geochemical Congress, held during June of 2018 in Bogotá (Colombia; Fig. A3.3.1).

- ***Kayak training***: During 2018 all the members of the Geological Unit were trained in the use of kayaks. The use of kayaks will be soon implemented as part of the geochemical sampling of rivers in southern Chile.

Figure A3.3.1. *Staff from the Geology and Mines Commission of Guyana (GGMC) and Geochemical Unit of Geological Survey of Chile (SERNAGEOMIN), during geochemical sampling in southern Guyana.*

A3.3.2. Colombia

Report by Gloria Prieto (Colombian Geological Survey)

During 2018, the Colombian Geological Survey developed geochemical samplings related to low-sampling density geochemical mapping as part of the global geochemical baseline project. In addition, geochemical sampling was carried out to identify geochemical anomalies and to evaluate the potential of mineral resources, as well as geochemical sampling of mineral deposits, and sampling for geochemical studies applied to environment and health.

A3.3.2.1. Low Density Geochemical Mapping in Colombia for the Global Geochemical Baselines

Since 2016, the Colombian Geological Survey (SGC) signed a cooperation agreement with the Geological Survey of China to perform a low-sampling density mapping in Colombia, as an input for the geochemical map of the world, and to advance the geochemical mapping of Colombia with sampling at higher sampling density. In development of the agreement a sampling network was established for Colombia, based on the Global Terrestrial Network (GTN). The Colombian territory is covered by 47 GTN cells of 160 x 160 km, which in turn were subdivided into 212 cells of 80 x 80 km. In each cell, the basins with catchment areas between 200 and 6,000 km^2 were delimited, and subsequently 623 basins were selected, and the sampling began at the end of 2017 and continued in 2018 (Fig. A3.3.2).

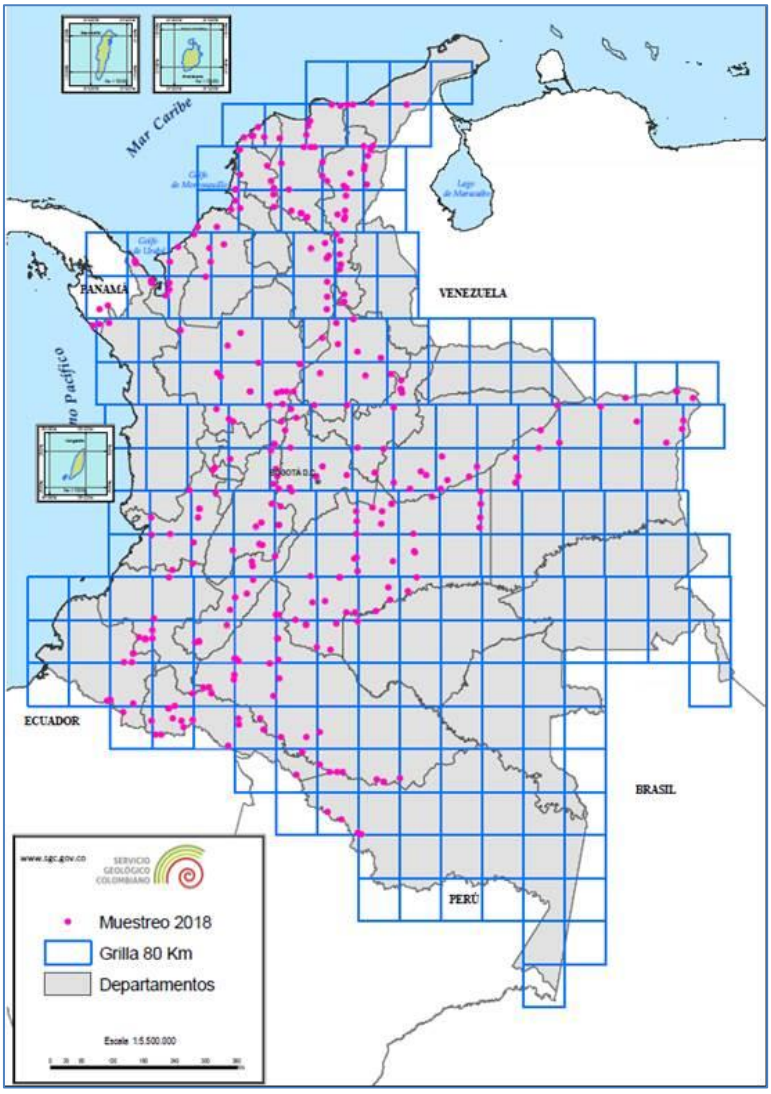

Figure A3.3.2. Map of Colombia, scale 1: 5,500,000 with sub-cells of 80 x 80 km (212 cells) and sampling points covered in 2018 (n=328).

In 2018, approximately 65% of the Colombian territory was covered. Of the 212 sub-cells (80x80 km) selected for sampling in Colombia, 95 sub-cells were covered with 328 sampling sites. Taking into account Colombia's information needs, samples of surface water and floodplain or overbank sediment samples were collected at each site (Fig. A3.3.3). The stream water samples were analysed in the laboratories of the SGC and the analytical data together with the quality control parameters (QA / QC) were archived in the EXPLORA database of the Directorate of Mineral Resources.

Figure A3.3.3. Sampling of floodplain using a trench of 170 cm depth.

In execution of the Agreement between the SGC of Colombia and the CGS of China, the floodplain samples (overbank or floodplain sediment) were packed following protocols established by the SGC and sent to the laboratories of the Geological Survey of China to perform the different chemical analysis (Fig. A3.3.4).

Figure A3.3.4. Samples sent for analysis in the laboratories of China Geological Survey.

A3.3.2.2. First Latin American Workshop on Geochemical Mapping

In compliance with the objectives of the cooperation agreement between China Geological Survey and the Colombian Geological Survey, the First Latin American Geochemical Mapping Workshop was held from the 5th to the 8th June 2018 in Bogota, which included the participation of representatives from Brazil, Chile and Mexico (Fig. A3.3.5).

The workshop included lectures and discussions on methodologies and experiences in geochemical sampling of the different participating countries. During the event, a field trip was organised to the municipality of Paipa where the methodologies used by the SGC and the CGS for the collection of samples of stream water and sediments (floodplain and overbank) for projects of geochemical mapping were demonstrated and discussed (Fig. A3.3.6).

Figure A3.3.5. Participants in the First Latin American Geochemical Mapping Workshop, with representatives from Brazil, Chile, Mexico, China and Colombia.

Figure A3.3.6. Fieldtrip organised during the First Latin American Geochemical Mapping Workshop.

A3.3.2.3. Geochemical Atlas of Colombia

Using all the new information generated in the projects executed by the Colombian Geological Survey, new geochemical maps of Colombia were produced. In the first trimester of 2019 a new version of the Geochemical Atlas of Colombia (AGC version 2018) will be published.

Additionally, new information coming from the geochemical research done in mineral deposits will be included in the new version of the Metallogenic Map of Colombia that will be published in 2019 (MMC version 2018).

A3.3.2.4. Geochemical Sampling to Evaluate Potential of Mineral Resources

In the execution of high-sampling density geochemical sampling to evaluate the potential of mineral resources, seven areas were sampled (Norcasia, San Diego, San Alberto, Ocaña, Tarso, Nariño, Marquetalia), where stream sediments and rock samples were collected from outcrops with metallogenic interest (contact zones, alteration, mineralisation) (Fig. A3.3.7). The samples were packed and sent to the laboratories of the SGC and external to perform the respective chemical analyses, and the field and analytical information archived in the EXPLORA geodatabase. The information was processed using specialised software (Geosoft, Iogas, ArcGIS, SPSS, among others), geochemical anomalies were identified, concentration and distribution maps were produced. By integration with geological, geophysical and metallogenic information, targets were identified for mineral exploration.

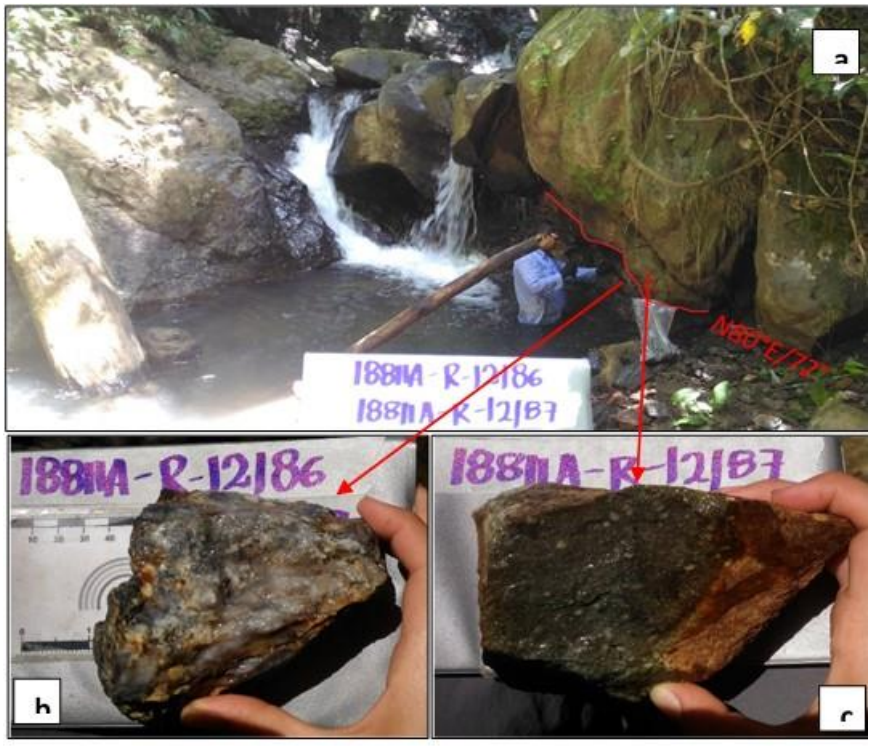

Figure A3.3.7. Sampling of rocks.

A3.3.2.5. Geochemical Sampling for Environmental Geochemistry and Geomedicine

Related to geochemical sampling for environmental and health applications, systematic sampling was carried out in areas where high arsenic contents have been reported in surface water. In these areas, samples of surface water, groundwater, stream and suspended sediments, soils and rocks were collected (Figs. A3.3.8 & A3.3.9). Additionally, research on mercury and other potentially hazardous elements continued in the coal basins of the central part of Colombia.

Figure A3.3.8. Sampling of surface water for determination of arsenic and other potentially harmful elements.

Figure A3.3.9. Sampling of stream and suspended sediments for the determination of arsenic and other potentially harmful elements.

A3.4. ASIA

A3.4.1. China

Report by Xueqiu Wang (UNESCO International Centre on Global-Scale Geochemistry, Langfang, China)

A3.4.1.1. Development of global partners

- The IUGS Commission on Global Geochemical Baselines (IUGS CGGB) has promoted the Global Geochemical Baselines and has developed over many years an international cooperation network (see Section 8, and Members web page at the Commission's website). The UNESCO International Centre on Global-Scale Geochemistry (UNESCO-ICGG) has developed eleven new partners for global geochemical baselines with the following countries: Russia, Mongolia, Cambodia, Laos, Uzbekistan, Pakistan, Papua New Guinea, Indonesia, Turkey, Peru, and the Republic of Guinea, and has linked with four IUGS CGGB members: Chile, Colombia, Iran and Nigeria.

A3.4.1.2. Scientific Research Activities

- The China Government via China Geological Survey (CGS) has provided full support to the UNESCO ICGG for the Global Geochemical Baselines project. The ICGG has cooperated with Laos, Cambodia, Mongolia, Iran, Russia, Papua New Guinea, Colombia and the Republic of Guinea to carry out the global geochemical baselines sampling, based on the GTN grid cells of 160x160 km, and covered a total area of 4,900,000 km^2, with the collection of a total of 1144 global samples.
- The map of Figure A3.4.1 shows the location of sampling points in those countries that have either carried out continental-scale sampling or have plans to carry out such sampling. ***It should be noted that the sampling protocols are not consistent throughout the world, and the methods used to analyse the samples are, at the moment, not consisten*t**.

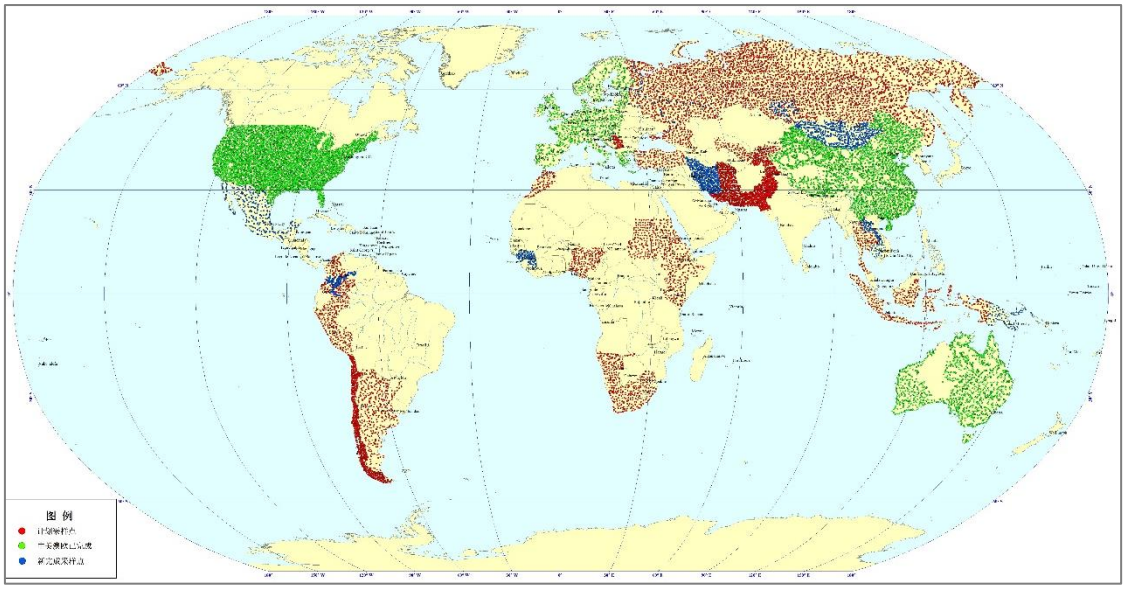

Figure A3.4.1. Map showing the location of sampling points in those countries that have either carried out continental-scale sampling or have plans to carry out such sampling. Green dot: Sample locations completed in Australia, China, Europe and USA; Blue dot: sample locations completed by the ICGG in cooperation with participating countries; Red dot: sample locations designed to be collected by the ICGG in cooperation with participating countries.

- The second-round sampling of China Geochemical Baselines, as a part of the Global Geochemical Baselines, is a pilot study for the assessment of temporal changes induced by human activities and natural processes, and has covered up to now an area of 9,300,000 km^2.

A3.4.1.3. International Symposium and Training Workshops

A Mapping Chemical Earth Conference and a total of 4 international training workshops on Geochemical Mapping were held for developing countries sponsored by China in 2018:

- **Mapping Chemical Earth Conference** was organised by the ICGG in Langfang, China from October 16-17, 2018. A total of 200 participants from 26 countries have taken part in the conference.
- The **1st Latin American Workshop on Geochemical Mapping** took place in Bogota, Colombia from June 3 to 9, 2018. In total, it was attended by 138 participants from Brazil, Chile, China, Colombia and Mexico. The purpose of the workshop was to share the latest geochemical mapping knowledge and experience, to guide Latin American countries to obtain high-quality harmonised geochemical data and maps. The workshop also discussed the Road Map of Latin America Geochemical Baselines Project.
  - Dr. Oscar Peredes, President of SGC delivered a welcome speech.
  - Dr. Gloria Prieto, Director of the Directorate of Mineral Resources and local organiser of the workshop, delivered an opening speech.
  - Dr. Xueqiu Wang, 2nd Co-chair of the IUGS CGGB has given presentations on (a) '*Geochemical Mapping: Principles and Methodology*', (b) '*Global Geochemical Baselines and Mapping Chemical Earth*', (c) '*Regional Geochemical Mapping: Case histories of gold and covered terrain exploration*', and (d) '*Soil Environmental Geochemical Mapping in China*'.
  - Mr. Geol. João H. Larizzatti from CPRM-Geological Survey of Brazil gave a presentation about the '*National Research Programme on Low Density Geochemistry*'.
  - Juan Pablo Lacassie Reyes from SERNAGEOMIN gave a presentation on '*Geochemical mapping in Chile*'.
  - Ricardo Cureño Suriano from SGM gave a presentation on '*Geochemical Cartography of High and Low Density*'.
  - Adrian Perez Avila from SGC gave a presentation on '*Geochemical Mapping in Colombia*'.

Field trip to a typical landscape near Duitama city was organised for sampling overbank sediment/soil sampling and water.

- **Peru Training Workshop on Geochemical Mapping** took place from August 22 to 24, 2018 in Lima, Peru. The workshop was particularly designed for the INGEMMENT and the China Geological Survey (CGS) geoscientists who participated in Peru Global Geochemical Baselines. Dr. Xueqiu Wang gave a presentation on '*Global Geochemical Baselines: Field Sampling, Laboratory Analysis and Data Applications*'. A one-day field training trip was conducted for overbank sediment sampling. The Road Map of Peru and China Cooperation Geochemical Mapping was discussed.
- The **2018 ICGG Training Workshop on Geochemical Mapping** took place in Langfang from October 9 to 17, 2018, sponsored by the China Geological Survey, Ministry of Natural Resources, P.R. China. In total, it was attended by 26 participants from 10 countries, including Kazakhstan, Pakistan, Madagascar, Russia, Italy, Brazil, Colombia, Nigeria, Sudan and Laos. The training courses involved the following topics, '*Global Geochemical Baselines and Mapping Chemical Earth*', '*Geochemical Mapping in Mineral Exploration*', '*The Methods and Some Achievements on Environmental*

Geochemical Mapping in China', '*Applied Geochemistry as an Essential Tool to Discriminate the Impact of Environment Contaminants on Human Health*', '*Geochemical Analytical Methods of 76 Elements*', '*Geocloud Data Management*', and a one-day field sampling trip for global sampling of floodplain/overbank sediment, including sample location selection, sample pit preparation, sampling horizon observation, sampling for surface samples and deep samples, completing sampling observation sheet and taking digital photographs.

- **The 2018 Training Courses for Developing Countries on Geochemical Mapping: Environments and Resources**, sponsored by the Ministry of Commerce, was held in Beijing from October 12 to November 1, 2018. In total, it was attended by 32 participants from 12 countries, including Thailand, Eritrea, Antigua and Barbuda, Cambodia, Zambia, Ethiopia, Sudan, Morocco, Vanuatu, Nigeria, Serbia and Tanzania. The training courses involved indoor lectures of Geological Mapping, Global-Scale and National-Scale Geochemical Mapping, Geochemical Data Processing Methods, Application of Geochemical Mapping Data in Mineral Resources and Environment, International Cooperation Proposals for Geochemical Mapping, the Role of Resources in Social and Economic Development, and Mining Policies of China. The field trip included demonstration of catchment sediment sampling, and a visit to Zijin Mines at Shanghang, Fujian Province in south-east China.

A3.4.1.4. Data Sharing

- Global Geochemical Atlas of 26 elements from the four continental-scale geochemical projects in USA, Australia, China and Europe, 50 elements from China EGMON data, 40 elements from China CGB data can be download from the ICGG website (www.globalgeochemistry.com)[5].

A3.4.1.5. Science Popularisation

- A science popularisation activity for '*Mapping Chemical Earth: Protecting Our Planet*' was held in Langfang, China on the World Earth Day on April 22, 2018, and more than 500 people attended the activities.
- A science popularisation speech '*Mapping Chemical Elements on the Earth*' was given by Dr. Xueqiu Wang at the China Geological Library on April 27, 2018.

A3.4.1.6. Funding provided by China

- China Government and China Geological Survey has provided financial support for the UNESCO ICGG, approx. US $2.5 million for training, sampling and laboratory analysis for global geochemical baselines in 8 countries in 2018.

[5] **IMPORTANT COMMENT**: It should be noted that the sampling protocols and the methods used to analyse the samples in these continental-scale projects are not consistent and, therefore, the data must not be presented on the same map. A recent paper compares continental-scale projects from North America, Europe, China and Australia, and quite rightly presents individual maps. The paper is: Caritat, P. de, Reimann, C., Smith, D.B., Wang, X., 2018. *Chemical elements in the environment: Multi-element geochemical datasets from continental- to national-scale surveys on four continents*. Applied Geochemistry, 89, 150-159; https://doi.org/10.1016/j.apgeochem.2017.11.010.

A3.4.2. Japan

Report by Atsuyuki Ohta (Geological Survey of Japan, AIST, Tsukuba)

A3.4.2.1. Japan Geochemical Mapping project

Japanese geology has a more complicated distribution than those of Europe, the United States of America, or China, which are situated on older continental terrains. To understand geochemical variety of surface materials in the island arc region, the exposed areas of various lithologies in drainage basins were assessed with 3024 stream sediment samples collected for the Japanese geochemical mapping project.

The stream network and drainage basin for each sampling location were obtained from a 50 m mesh digital elevation model based on a hydrological model of Geoinformation System program (ArcGIS 10.5). Obtained watershed polygons of 3024 samples in river system were superimposed on the 200,000 scale digital geological map of Japan (Geological Survey of Japan, AIST. (ed.) 2015. Seamless digital geological map of Japan 1: 200,000. https://gbank.gsj.jp/seamless/index_en.html). We assumed that a specific rock type outcropping more than half of the watershed area is the dominant rock, *i.e.*, it controls the chemical composition in stream sediments. According to the major Japanese lithologies, the stream sediment samples are classified into 13 different types: (i) unconsolidated sediments, (ii) sedimentary rock, (iii) sedimentary rocks of accretionary complexes, (iv) igneous rocks of accretionary complexes, (v) non-alkaline pyroclastic rocks, (vi) non-alkaline rhyolite and dacite, (vii) non-alkaline andesite and basalt, (viii) alkaline mafic volcanic rock, (ix) non-alkaline felsic intrusive rock, (x) granitic rock, (xi) gabbroic rock, (xii) high-pressure type, and (xiii) high-temperature type metamorphic rocks.

The classification is further sub-classified to more than 90 different rock types using rock age and rock formation field or tectonic belt.

Median values of 53 elemental concentrations were calculated to respective samples classified by the dominant lithology. The Chemical Index Alteration suggests that the chemical weathering process is less effective to formation of stream sediments from their host rocks in Japan. Chemical composition of stream sediments is approximately comparable to their host rocks. Therefore, the database of the chemical composition, as well as the dominant lithology, would be informative to understand chemical, mineralogical, and petrological variety of surface materials in the island arc region.

A3.5. AUSTRALASIA

A3.5.1. Australia

Report by Patrice de Caritat and Evgeniy Bastrakov (Geoscience Australia)

2018 saw the initial release of the Northern Australia Geochemical Survey (NAGS) results, a part of the Australian Government's 'Exploring for the Future' (2016-2020; EFTF) programme (http://www.ga.gov.au/eftf). NAGS was completed in 2017 in collaboration with the geological surveys of Northern Territory and Queensland (Fig. A3.5.1). NAGS targeted overbank/floodplain sediments at the downstream end of large hydrographic catchments at a density of approximately one sample per 500 km^2. Within 2018 to 2020, NAGS geochemical data, metadata and digital maps are released on an ongoing basis through Geoscience Australia's website (http://www.ga.gov.au/eftf/minerals/fis/nags). The first data release included information on the sampling sites (catchments and sample locations); bulk sample properties (Munsell colour, pH and EC); results of XRF analyses and ICP-MS analyses for the fine (<75 mm) fraction of the samples; and results of ICP-MS analyses of the MMI™ extractions (0-2 mm). Besides conventional data interpretation and maps, the current work includes machine learning processing and presentation of data, integrating geochemical, geological, geomorphological and climatic factors.

A3.5.1.1. Published papers and reports

Bastrakov, E. N., Main, P., Wygralak, A., Wilford, J., Czarnota, K. & Khan, M., 2018. *Northern Australia Geochemical Survey Data release 1 – Total (fine fraction) and MMI™ element contents*. Record 2018/06. Geoscience Australia, Canberra; http://dx.doi.org/10.11636/Record.2018.006.

Caritat, P. de & Mann, A., 2018. *An improved method for assessing the degree of geochemical similarity (DOGS2) between samples from multi-element geochemical datasets*. Geochemistry: Exploration, Environment, Analysis, online: https://doi.org/10.1144/geochem2018-021.

Caritat, P. de, 2018. *Continental-scale geochemical surveys and mineral prospectivity: comparison of a trivariate and a multivariate approach*. Journal of Geochemical Exploration, 188, 87-94; http://doi.org/10.1016/j.gexplo.2018.01.014.

Caritat, P. de, Reimann, C., Smith, D.B. & Wang, X., 2018. *Chemical elements in the environment: multi-element geochemical datasets from continental- to national-scale surveys on four continents*. Applied Geochemistry, 89, 150-159; http://doi.org/10.1016/j.apgeochem.2017.11.010.

Reimann, C., Fabian, K., Birke, M., Filzmoser, P., Demetriades, A., Négrel, P., Oorts, K., Matschullat, J., Caritat, P. de & GEMAS Project Team, 2018. *GEMAS: Establishing geochemical background and threshold for 53 chemical elements in European agricultural soil*. Applied Geochemistry, 88: 302-318; http://doi.org/10.1016/j.apgeochem.2017.01.021.

Talebi, H., Mueller, U., Tolosana-delgado, R., Grunsky, E.C., Mckinley, J.M. & Caritat, P. de, 2018. *Surficial and deep earth material prediction from geochemical compositions*. Natural Resources Research, online Nov 2018; http://doi.org/10.1007/s11053-018-9423-2.

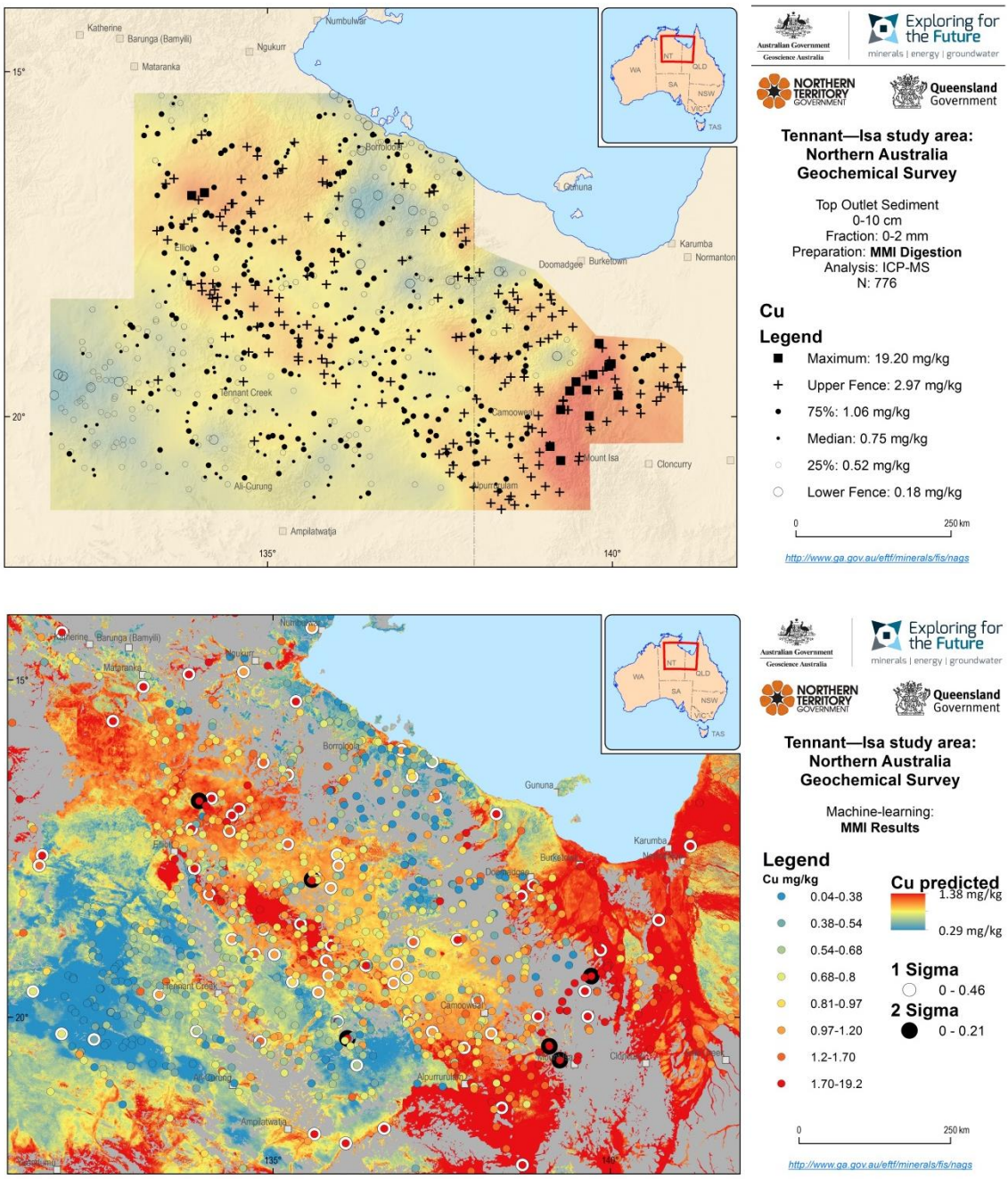

Figure A3.5.1. Map showing the distribution of copper in the Northern Australia Geochemical Survey (NAGS) samples over the Tennant Creek — Mt Isa study area. (A) Top map: The results of the MMI™ extraction (the sediment 0-2 mm fraction); (B) Bottom map: MMI™ Cu concentrations predicted by machine learning. Copper values above 1 and 2 σ values of the predictive model indicate sites where Cu concentration are clearly above the environmental background.

A3.5.1.2. Oral and poster presentations

Grunsky, E., Caritat, P. de & Mueller, U., 2018. *The use of surface regolith geochemistry to map the major crustal blocks of the Australian continent*. International Symposium on Deep Earth Exploration and Practices (DEEP-2018) (Beijing, China, 24-26 October 2018), Oral Presentation, Abstract.

Chua, S., Wilford, J., Caritat, P. de & Champion, D., 2018. *A machine learning approach to national scale predictive geochemical maps*. 2018 Australian Geoscience Council Convention (AGCC) (Adelaide, Australia, 14-18 October 2018), Poster Presentation, Abstract #639, Abstract Volume: 632.

Mann, A.W., Caritat, P. de, Lilly, R. & Sylvester, G., 2018. *Mineralisation-related element dispersion and anomaly context from regional and prospect scale multi-element soil data*. RFG2018 (Resources for Future Generations) Conference (Vancouver, Canada, 16-21 June 2018), Oral Presentation, Proceedings: Abstract 1125.

Caritat, P. de, Cracknell, M., Grunsky, E., Main, P. & Mann, A., 2018. *Continental-scale mineral prospectivity assessment using the National Geochemical Survey of Australia (NGSA) dataset*. RFG2018 (Resources for Future Generations) Conference (Vancouver, Canada, 16-21 June 2018), Oral Presentation, Proceedings: Abstract 1249.

Smith, D.B., Demetriades, A., Caritat, P. de & Wang, X., 2018. *Global-scale geochemical data in the exploration for and development of mineral resources for future generations*. RFG2018 (Resources for Future Generations) Conference (Vancouver, Canada, 16-21 June 2018), Keynote Presentation, Proceedings: Abstract 1453.

Bastrakov, E. N., Wilford, J., Caritat, P. de , Main, P., Wygralak, A. & Chua, S. 2018. *A machine-learning interpretation of regional geochemical patterns in northern Australia*. Geoanalysis 2018: 10th International Conference on the Analysis of Geological and Environmental Materials: Sydney, Macquarie University, p. 29.

Main. P., Bastrakov, E., Wilford, J., Czarnota, K. & Wygralak, A. 2018. *The Northern Australia Geochemical Survey - a potential method for discovering undercover mineralisation*. Australian Geoscience Council Convention 2018: Adelaide, p. 69.

A3.5.2. New Zealand

Report by Adam Martin (GNS Science)

A publication was released incorporating geochemical baseline data into mapped zones of shallow groundwater quality in New Zealand for the Farm Planning Environment workshop (see Section A3.5.2.1). A report on urban geochemical baseline mapping in Dunedin City, was published (GNS Science Report; Section 3.5.2.1), and new data normalisation techniques were applied to data to help vector towards orogenic-style mineralisation (AusIMM NZ extended abstract; Section A3.5.2.1). An M.Sc. thesis in the Department of Chemistry, University of Otago, was successfully defended: it examined strontium isotopes in soil over southern New Zealand (Section A3.5.2.2). Presentations on using geochemical baseline data were given at several New Zealand conferences (see Section A3.5.2.3).

No new samples were collected this year, but several avenues for additional funding from the New Zealand government and in-kind funding were explored. One additional manuscript, examining novel data treatment techniques of chemistry in soil is under review, with other manuscripts in an advanced state of preparation.

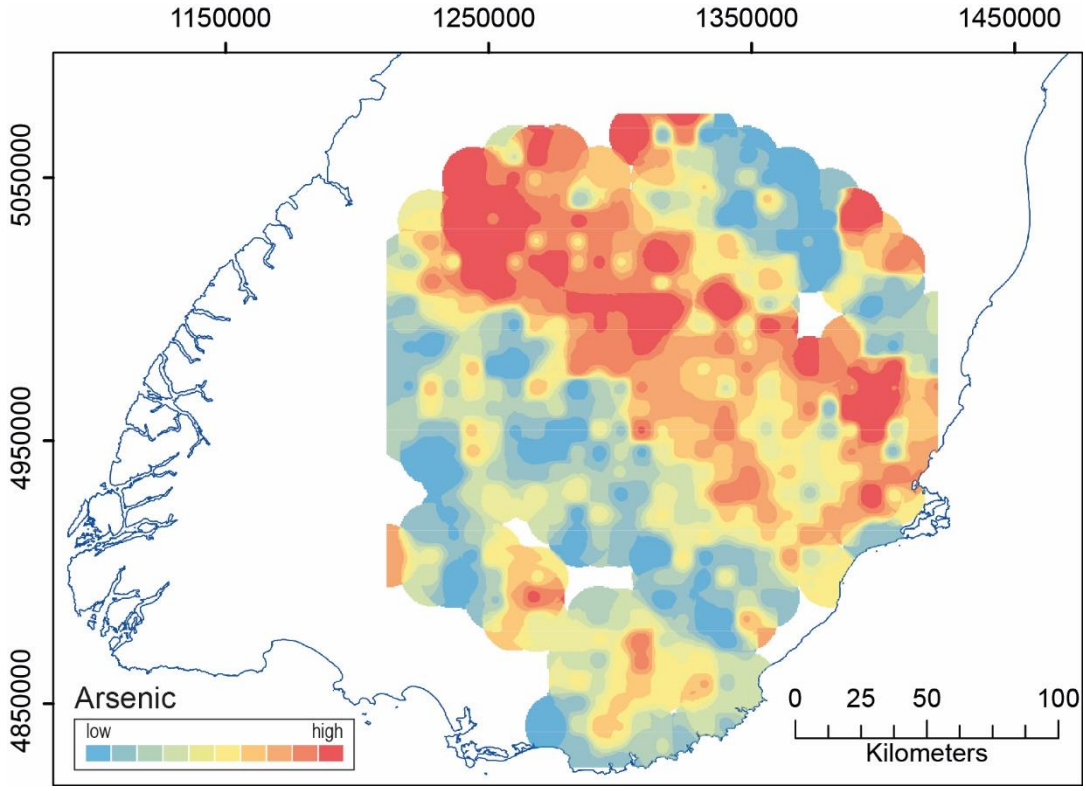

Figure A3.5.1. Arsenic in soil data plotted as a colour map (quantile). Warm colours equal higher concentrations.

A3.5.2.1. Published papers

Gazley, M.F., Martin, A.P., Turnbull, R.E., Frontin-Rollet, G. & Strong, D.T., 2018. *Vectors to orogenic-style mineralisation in southern New Zealand using standardised and transformed chemistry in soil*. In: Bull, V. (Editor), Australasian Institute of Mining and Metallurgy 51st New Zealand Branch Annual Conference, Tauranga, New Zealand, pp. 137-143.

Rissmann, C., Pearson, L., Lindsay, J., Beyer, M., Marapara, T., Badenhop, A., Couldrey, M. & Martin, A.P., 2018. *Integrated landscape mapping of water quality controls for farm planning: applying a high resolution physiographic approach to the Waituna catchment, Southland*. 19 pp. In: Currie, L.D.; Christensen, C.L. Farm environment planning: science,

policy and practice: 31st annual FLRC Workshop held at Massey University, February 2018. Palmerston North, N.Z.: Fertilizer and Lime Research Centre, Massey University. Occasional report / Fertiliser & Lime Research Centre, Massey University 31.

Turnbull, R.E., Martin, A.P., Rattenbury, M.S., Rogers, K.M., Strong, D.T. & Morgenstern, R., 2017. *Urban geochemical atlas of Dunedin City, New Zealand*. Lower Hutt, N.Z.: GNS Science. GNS Science report 2017/31. 187 pp.; http://doi.org/10.21420/G22P8N.

A3.5.2.2. Thesis

Amy Tredwell, 2017. *$^{87}Sr/^{86}Sr$ Isotope Ratios and Elemental Compositions of Partially Extracted Soil from the Otago-Southland Region of New Zealand*. M.Sc. thesis, Department of Chemistry, University of Otago, New Zealand, 116 pp.

A3.5.2.3. Oral and poster presentations

Australasian Institute of Mining and Metallurgy (AusIMM) 51st New Zealand Branch Annual Conference, Tauranga, New Zealand, 10-13 September 2017

Gazley, M.F., Martin, A.P., Turnbull, R.E., Frontin-Rollet, G. & Strong, D.T., 2018. *Vectors to orogenic-style mineralisation in southern New Zealand using standardised and transformed chemistry in soil*.

Geoscience Society of New Zealand Annual Conference 2017 : dynamic New Zealand, dynamic earth: University of Auckland, November 28 - December 1, 2017

Martin, A.P., Rattenbury, M.S., Strong, D.T. & Turnbull, R.E., 2017. *A geochemical baseline soil survey over Otago-Northern Southland*.

14th Australasian Environmental Isotope Conference (AEIC) : Museum of New Zealand Te Papa Tongarewa, Wellington, New Zealand, March 26 – March 28 March 2018

Rogers, K. M., Turnbull, R.E., Martin, A.P., Frontin-Rollet, G.E. & Rattenbury, M.S., 2018, *Evaluating anthropogenic influences on New Zealand regional and urban soils using multi-isotopes and elements*.

A3.6. EUROPE

Report by Philippe Négrel and Anna Ladenberger (EuroGeoSurveys Geochemistry Expert Group)

The main activities of the EuroGeoSurveys Geochemistry Expert Group during 2018 were:

- The organisation of the joint annual business meeting of the EuroGeoSurveys Geochemistry Expert Group and IUGS Commission on Global Geochemical Baselines in Madrid in May 2018 (see Appendix 1);
- The organisation of a session at the EGU meeting in Vienna, Austria (April 2018);
- Participation in RFG2018 (June 2018), Vancouver, Canada;
- Search for funding the second pan-European Urban Geochemical Mapping project, based on the manual:

Demetriades, A. Birke, M., 2015. Urban Topsoil Geochemical Mapping Manual (URGE II). EuroGeoSurveys, Brussels, 52 pp.; http://www.eurogeosurveys.org/wp-content/uploads/2015/06/EGS_Urban_Topsoil_Geochemical_Mapping_Manual_URGE_II_HR_version.pdf.

- Continued work on the GEMAS project samples and data, with the publication of five papers and the Italian GEMAS atlas:

Cicchella D., Zuzolo D., Albanese S., Dinelli E., Lima A., Valera P., De Vivo B., 2018. Geochemical Atlas of agricultural and grazing soils of Italy – The GEMAS project in Italy. Aracne Editrice, Roma, 352 pp.; http://www.aracneeditrice.it/index.php/pubblicazione.html?item=9788825516401.

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