2020
ANNUAL REPORT

of the

INTERNATIONAL UNION OF GEOLOGICAL SCIENCES
COMMISSION
ON
GLOBAL GEOCHEMICAL BASELINES

January 2021

Blank back page

CONTENTS

Blank back page

2020 ANNUAL REPORT of the
IUGS COMMISSION ON GLOBAL GEOCHEMICAL BASELINES

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

1. TITLE OF CONSTITUENT BODY

IUGS Commission on Global Geochemical Baselines (CGGB or Commission), and for the sake of brevity will henceforth be referred to as Commission.

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.

The global geochemical database is urgently needed by environmental and natural resource managers throughout the world. To reach this goal, the Commission established an international network of applied geochemists throughout the world in order to provide 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 terrains.
- ✓ 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 climate 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 natural 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

The Commission's Steering Committee members for the 2020-2024 period are:

Co-Chairs: *1st Co-chair*: Anna Ladenberger, Geological Survey of Sweden
2nd Co-chair: Kate V. Knights, Consultant Geochemist, Dublin, Ireland
Deputy-Chairs: *1st Deputy-chair*: Gloria Prieto, Servicio Geológico Colombiano
2nd Deputy-chair: Gloria Simubali, Geological Survey of Namibia
Scientific Secretary: Paula Adánez, Instituto Geológico y Minero de España
Public Relations and Finance: Ariadne Argyraki, Department of Geology and Geoenvironment, National and Kapodistrian University of Athens
Treasurer: Christina Stouraiti, Department of Geology and Geoenvironment, National and Kapodistrian University of Athens
Advisory Panel: David B. Smith, United States Geological Survey
Patrice de Caritat, Geoscience Australia
Alecos Demetriades, Institute of Geology and Mineral Exploration, Hellas

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 Terrestrial Network (GTN) 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, Mangosuthu University of Technology, Durban, KwaZulu-Natal, South Africa
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
Robert G. Garrett, Ottawa, Ontario, Canada
Flor de Maria Harp Iturribarría, SGM, Pachuca de Soto, Hidalgo, Mexico
Enrique Espinosa, SGM, Pachuca de Soto, Hidalgo, Mexico
Jessica Rivera Perez, SGM, Pachuca de Soto, Hidalgo, Mexico

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, Servicio Nacional de Geología y Minería, Valdivia, Chile
Gloria Prieto, Servicio Geológico Colombiano, Bogotá, Colombia

4.6.4. Australasia

Patrice de Caritat, Geoscience Australia, Canberra, Australia
Adam Martin, GNS Science, Avalon, Lower Hutt, New Zealand

4.6.5. China

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

4.6.6. Europe

Philippe Négrel, Bureau de Recherches Géologiques et Minières, Orléans, France
Anna Ladenberger, Geological Survey of Sweden, Uppsala, Sweden

Jasper Griffioen, Geological Survey of The Netherlands (TNO), Utrecht, The Netherlands

4.6.7. Indian Subcontinent

Pradip Govil, National Geophysical Research Institute, Hyderabad, India
Ashvin Wickramasooriya, South Eastern University of Sri Lanka, Sammanthurai, Sri Lanka

4.6.8. Japan

Atsuyuki Ohta, Geological Survey of Japan, AIST, Tsukuba, Japan

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 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.*

After the October 2018 meeting of the UNESCO Centre's Governing Board and Scientific Committee (refer to the 2019 Annual Report), it was expected that the collaboration between the Centre and the Commission was going to be smooth as five of the Commission's 2016-2020 Steering Committee members are also members of the Centre's Governing Board and Scientific Committee, and the Centre's Executive Director was the 2nd Co-chair of the Commission until 2020. However, this expectation was finally proved to be deceptive. There is minimal communication and collaboration between the Centre and the Commission. The Centre does not even inform its international Governing Board and Scientific Committee members of its activities except for once every two years just before the scheduled biennial meeting of the

Governing Board and Scientific Committee. After four-and-a-half years of the Centre's operation, the hope that the situation will change is, unfortunately, extremely doubtful.

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 four 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 (see 2014 Annual Report, p.25); (ii) 4th YES Congress in Tehran, Iran (29-30 August 2017), with 48 attendees (see 2017 Annual Report, p.28-34); (iii) RFG2018 in Vancouver, Canada (18 & 22 June 2018) – (see 2018 Annual Report, p.14-16 & 51-63), and (iv) on the occasion of the 5th YES Congress in Berlin (8-9 September 2019) – see 2019 Annual Report, p.18-19). This collaboration is continuing with the organisation of workshops on the occasion of future YES Congresses. There is also an on-going discussion about the establishment of a YES Working Group on Applied Geochemistry.

EuroGeoSurveys also established cooperation with the Organisation of African Geological Surveys (OAGS) and developed a pan-African geological project proposal (PanAfGeo), which is financed by the European Commission (Directorate-General of Development and International Cooperation) and by a Consortium of 12 European Geological Surveys coordinated by the French Geological Survey (BRGM). 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) covered 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 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 PanAfGeo project was completed in 2019, and the final meeting took place from 24-25 October 2019 in Dar es Salaam, Tanzania. One of the EuroGeoSurveys Geochemistry Expert Group and Commission members, Maria João Batista (Laboratório Nacional de Energia e Geologia, Amadora, Portugal) has given geochemistry training in Portuguese in Work Package 4 – Environmental Management of Mines in Tete, Mozambique. The content of the lessons was from basic chemistry to case studies of waste management, also including metal mobility, sampling of solid mine waste material, analytical methods, lixiviation tests, and quality control.

Geochemical mapping was also in the programme of the Geoscientific Mapping, which was coordinated by the Geological Survey of Czech Republic without collaboration with the EuroGeoSurveys Geochemistry Expert Group.

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 funding should be sought from other sources. Hence, the AfriGEOSS proposal was discussed with the EGS Secretary General, and Philippe Négrel, Chairperson of the EGS Geochemistry Expert Group will be discussing with the AfriGEOSS capacity building programme 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).

In South America, the Commission has established in 2019 a link with the Geochemistry Working Group of the Asociación de Servicios de Geología y Minería Iberoamericanos (ASGMI: http://asgmi.org/en/).

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 in 2018 annual report of IUGS-CGGB), 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 in 2018 annual report of IUGS-CGGB).

5.2.1. New collaboration link with FAO's GLOSOLAN project

Following information sent by Fiona Fordyce (IUGS-CGGB United Kingdom member), the Commission joined on the 12th of March 2019 the discussion forum of the Global Soil Laboratory Network (GLOSOLAN: http://www.fao.org/global-soil-partnership/pillars-action/5-harmonization/glosolan/en/). A confidentiality agreement was signed, as this was a requirement for the participation in the GLOSOLAN programme.

GLOSOLAN's main objectives are:

- Make soil information across labs, countries and regions comparable, interpretable;
- Build a set of agreed harmonisation principles;
- Improve quality assurance and control (QA/QC) of soil analyses, and
- Promote information and experience exchange.

The discussion is made through video conferences, and up to now there were two video conferences, and a meeting in the FAO premises Rome on the 28th and 29th October 2019, which it was not attended by the Commission due to lack of funds.

5.2.2. Possible collaboration with the Global Observatory on Pollution and Health

In 2019, the Commission initiated contact with the Global Observatory on Pollution and Health. The Global Observatory was established in 2018 as a collaborative effort among Boston College, the United Nations Environment Program, and the Center for Climate, Health, and the Global Environment at the Harvard T.H. Chan School of Public Health. The primary goal of the Global Observatory is to track efforts to control pollution and prevent pollution-related diseases. Mapping will be an important function of the Global Observatory. Data collected from various sources will be geocoded and entered into a Geographic Information System model for each country. Global-scale geochemical data sets from the IUGS Commission on Global Geochemical Baselines are a potentially important source of information for the Global Observatory. These data sets will provide a better understanding of the natural variation of potentially toxic elements in the Earth's near-surface environment and will provide a baseline against which future changes in the geochemistry caused either by human activities or natural processes may be recognised. Brief articles about the Global Observatory can be found at https://www.bc.edu/bc-web/centers/schiller-institute/programs/global-observatory-on-pollution-and-health.html, and https://www.unenvironment.org/news-and-stories/press-release/un-environment-and-boston-college-establish-global-pollution.

6. ACTIVITIES IN 2020

6.1. 74th IUGS EXECUTIVE COMMITTEE MEETING

The 74th IUGS Executive Committee (EC) meeting was organised in Busan of South Korea from the 15th to the 18th of January 2020. The open session was on the 15th and 16th of January 2020.

At the open session of the EC meeting the IUGS-CGGB Treasurer reported the Commission's 2019 activities, and the 2020 programme, as well budget requirements. The IUGS Executive Committee was pleased with the progress made on the two standard geochemical methods manuals, as the work of the Commission is to put in place standards for establishing geochemical baselines, and geochemical work in general, which can be used by the broad Earth Science community, as per the IUGS definition of Commissions.

The '*International Union of Geological Sciences Manual of Standard Geochemical Methods for the Global Black Soil Project*' was completed, and a hard copy was submitted to the EC for approval at its closed meeting (see Section §6.8).

The work on the '*International Union of Geological Sciences Manual of Standard Methods for Establishing the Global Geochemical Reference Network*' is still continuing. The plan, or rather the attempt, was to complete the manual by the end of 2020 in order to be approved by the 2016-2020 IUGS Executive Committee. However, the job is more difficult than originally anticipated, because many people from all over the World are involved, and one of the problems is that the agreed deadlines are not always kept, because of either Geological Survey or contract work. This applies also to the external reviewers. Hence, the plan is to complete and publish it, hopefully, in 2021.

At this meeting, Roland Oberhänsli (Chair of the Ad-hoc Review Committee and IUGS President 2012-2016) presented the report of the Ad hoc Review Committee, which was carried out in Athens on the 15th and 16th of November 2019 (see pages 31-33 of the Commission's 2019 Annual Report).

6.2. ANNUAL BUSINESS MEETING

The planned joint annual business meeting of the IUGS Commission on Global Geochemical Baselines and EuroGeoSurveys Geochemistry Expert Group in Athens (Hellas) on the 5th and 6th of November 2019 was cancelled because of the Covid-19 pandemic.

6.3. STEERING COMMITTEE VIRTUAL MEETINGS

Two virtual Steering Committee meetings were organised. The first one on the 25th of June 2020, which was chaired by the outgoing 1st Co-chair Dave Smith. At this meeting all outgoing members of the Steering Committee participated together with all new members. The minutes of this meeting are in Appendix 1.

The second virtual meeting of the Commission's Steering Committee was held on the 2nd of October 2020 and was chaired by the new 1st Co-chair Anna Ladenberger. The minutes of the second virtual meeting are in Appendix 2.

6.4. EXTRAORDINARY SESSION OF THE IUGS-IGC COUNCIL

According to the IUGS Statutes and Bylaws, the IUGS Council meets every four years on the occasion of the International Geological Congress (see Section §6.6.1). The Commission prepared a concise report about its activities from 2016 to 2020 and an oral presentation (see Appendix 3). The four-year 2016-2020 report was submitted to the IUGS Secretary General and the IUGS Secretariat on the 6th of February 2020.

The virtual Extraordinary Session of the IUGS-IGC Council was held from the 28th to the 30th of October 2020. Almost all members of the Commission's Steering Committee attended the Extraordinary Session. The 2016-2020 summary report was presented by Alecos Demetriades (Advisory Panel member and past Treasurer). The 2016-2020 summary report is available from the Commission's website, and the slides of the PowerPoint presentation are in Appendix 3.

6.5. OTHER MEETINGS AND WORK PERFORMED

6.5.1. GeoMORE virtual meeting, 15th October 2020

GeoMORE (Geoscientific Mapping of the Ocean Realm) was approved as a scoping study for the ocean realm at the 74th IUGS Executive Committee meeting in January 2020. The Commission has undertaken to provide the marine 160x160 km grid cells covering the seas, lakes and oceans, and also the 5 and 8 random points for planning the sampling campaign.

Essentially this is the extension of the terrestrial network to the marine realm (Figures 1, 2 & 3). The Commission's Sampling Committee Chair presented the Global Marine Network grid cells, and random sample sites (see below).

6.5.1.1. Global Marine Network (GMN) grid cells and random samples

The Commission's Sampling Committee Chair got in touch with Xiaoyuan Geng and Juanxia He (Canadian Soil Information Service, Science and Technology Branch, Agriculture and Agri-Food Canada, http://sis.agr.gc.ca/), the colleagues who generated the terrestrial random sample sites. Using the same computer routines, they generated in early October 2020 the 5 and 8 random points within each Global Marine Network (GMN) grid cell of 160 x 160 km. 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 proposed in the 'Blue Book' (Darnley *et al.*, 1995, p.2 and 44), and countries are free to select which sampling density they will be using. Although the 'Blue Book' was written for the terrestrial environment, the philosophy therein for planning the sampling campaign can be applied to the marine environment too.

The Global Marine Network (GMN) file with 12,477 grid cells of 160x160 km was compiled by subtracting the 7356 grid cells of the Global Terrestrial Network (GTN) from the 19,833 grid cells of the Global Reference Network (GRN) – see Figure 1.

Planning the sampling campaign of the marine environment, the recommendation is to extend the random sampling design of the terrestrial domain to the marine realm. The continental-scale FOREGS Geochemical Atlas of Europe has proven that the 5-random sampling site scheme in each 160x160 km grid cell is cost-effective, and produces interpretable results, *i.e.*, providing the geochemical baseline against which future changes may be recognised and quantified. Of course, only large continental-scale geochemical patterns are visible at this wide-spaced sampling scheme. As the 'Blue Book' by Darnley *et al.* (1995) recommends also 8-random sampling sites in each 160x160 km grid cell, these are given too but not recommended, especially for the marine environment mainly because of costs and practical difficulties.

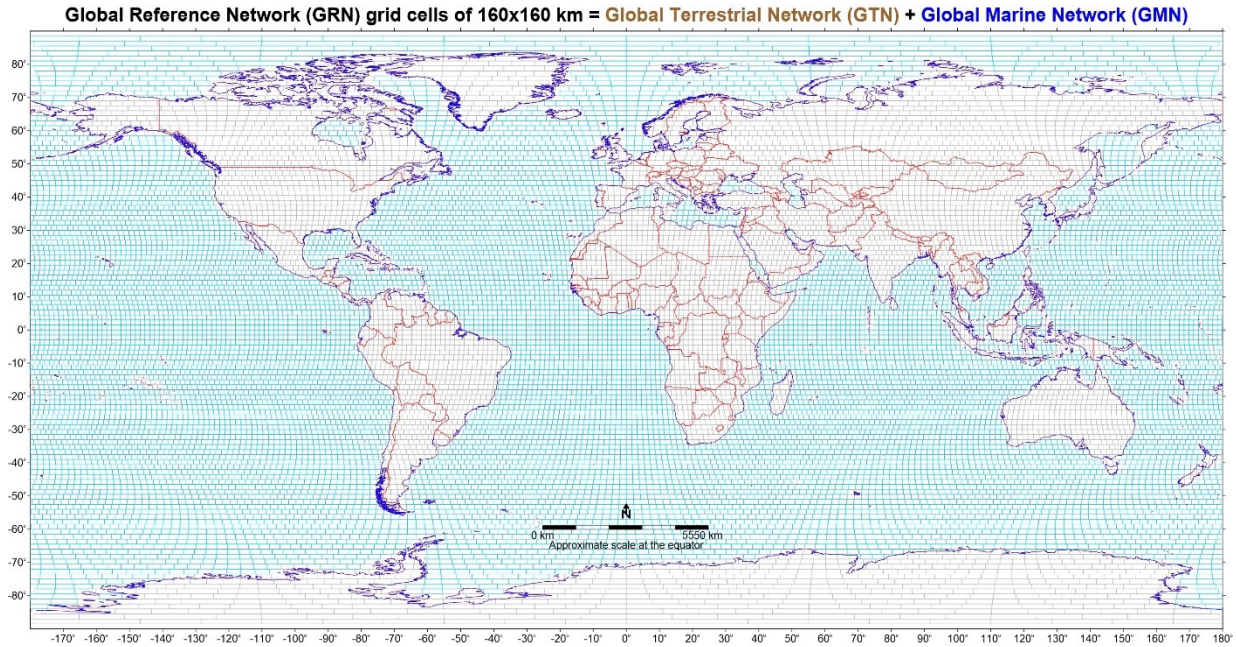


Figure 1. The map shows the Global Reference Network (GRN) with the 19,833 grid cells of 160x160 km, which includes the Global Terrestrial Network (GTN) of 7356 grid cells, and the Global Marine Network (GMN) of 12,477 grid cells. Map plotted with Golden Software's MapViewer™ v8 by Alecos Demetriades, I.G.M.E. & IUGS-CGGB.

The sampling points in each Global Marine Network (GMN) grid cell of 160x160 km are totally randomised and are not designed to show the lowest natural background concentrations in the global marine environment, but to demonstrate the current geochemistry of the surface and sub-surface sediments, and possibly the sea water column (Figure 2).

Some GMN cells are located in more than one country's marine jurisdiction. In these cases, the sampling of that particular GMN grid cell is coordinated by the country (organisation) in which the centre of the grid cell is located.

In the Microsoft Excel files, country names are not given for each random point because not all countries have defined their continental shelves and Exclusive Economic Zones. As there are still disputes between neighbouring countries, it was considered prudent not to assign country names to sample sites and GMN grid cells.

The Marine Regions Organisation has a database for the Global Exclusive Economic Zones according to the 1982 United Nations Convention on the Law of the Sea over which a sovereign state has special rights regarding the exploration and use of marine resources, including energy production from water and wind. For further information about this database the Marine Regions Organisation website should be consulted at https://www.marineregions.org/.

On the map of Figure 2 there are no random points in grid cells near the coastal zone of countries, and around islands. The reason is that these random sites are included in the Global Terrestrial Network Microsoft Excel files, which should be downloaded from the relevant web page (https://www.globalgeochemicalbaselines.eu/content/111/sampling-design-/). Figure 3 shows both the 5 terrestrial and 5 marine random sites.

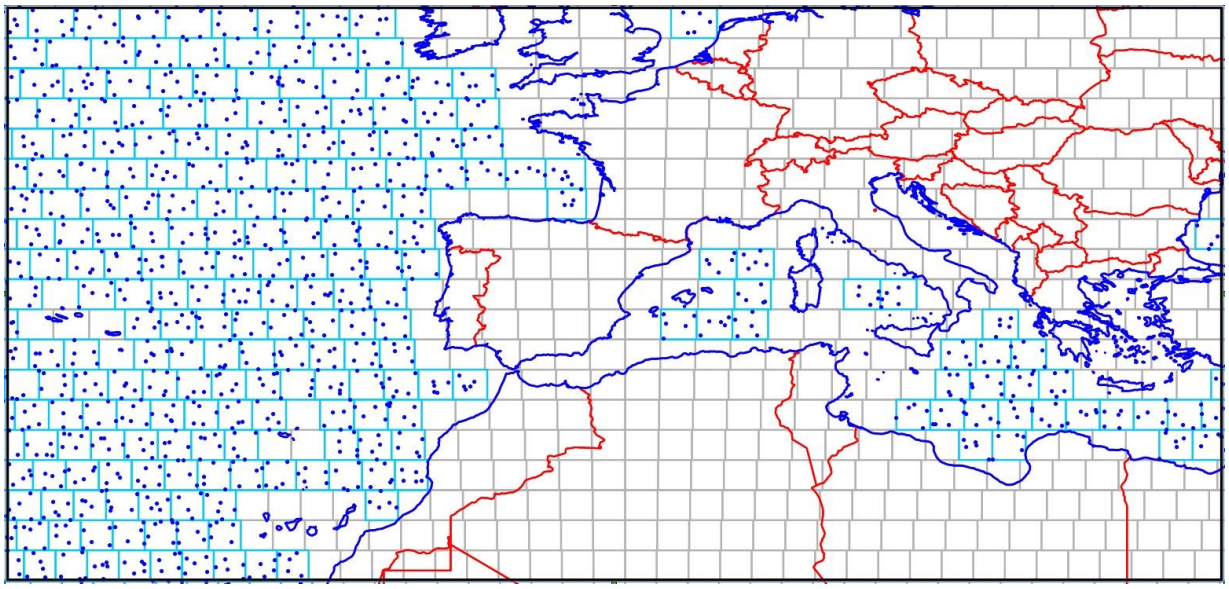


Figure 2. The map shows the 5 random sites (blue dots) within the 160x160 km grid cells in the marine realm (the philosophy of the random sites is explained on the web page of the GTN sampling design, which should be consulted). Map plotted with Golden Software's MapViewer™ v8 by Alecos Demetriades, I.G.M.E. & IUGS-CGGB.

6.6. INTERNATIONAL CONFERENCES: SESSIONS AND WORKSHOPS

In 2020, the Commission planned to actively participate in two International Conferences, namely the 36th IGC in Delhi (India), and the joint 5th ISEH and 6th ICEPH in Galway (Ireland), which were postponed due to the Covid-19 pandemic. However, Commission Steering Committee members participated in a number of virtual events as detailed below.

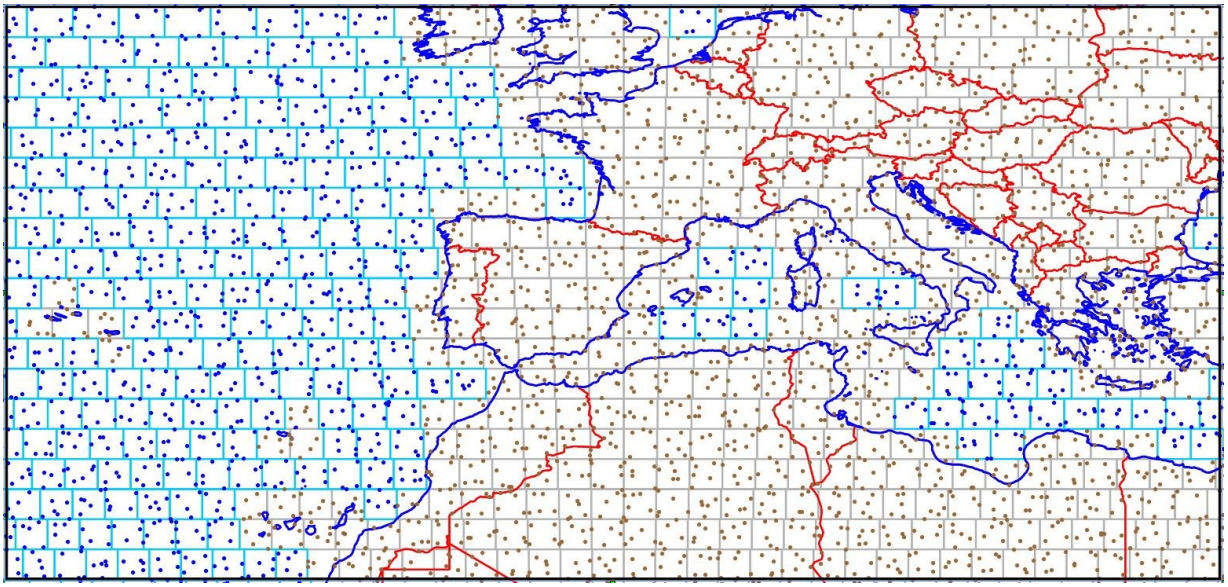


Figure 3. The map shows the 5 random sites within the 160x160 km grid cells of both the marine (blue dots) and terrestrial (brown dots) parts of our home planet Earth. Map plotted with Golden Software's MapViewer™ v8 by Alecos Demetriades, I.G.M.E. & IUGS-CGGB.

6.6.1. 36th International Geological Congress, Delhi, India, 2-8 March 2020

The Commission planned two events on the occasion of the 36th International Geological Congress in Delhi, namely:-

(i) the '*4th Arthur Darnley Symposium: Challenges and opportunities of Global-scale geochemical mapping*' (accepted 12 abstracts for oral presentation, and 7 abstracts for posters)

(ii) a two-day workshop with the title '*Geochemical mapping at all scales: Continental, regional and local*' (in total 39 registrations). The workshop tutors would have been Alecos Demetriades (Commission's Chair of Sampling Committee), David Cohen (Professor of Geochemistry, University of New South Wales, Sydney, Australia) and Philippe Négrel (Head of Chemical Laboratories), Bureau de Recherches Géologiques et Minières, France).

The postponement of the 36th International Geological Congress was a disappointment for applied geochemists participating with oral and poster presentations at the 4th Arthur Darnley Symposium, and to the 39 people that would have attended the two-day workshop.

6.6.2. 8th Session of the Global Soil Partnership Plenary Assembly

Commission Steering Committee members participated in the virtual 8th GSP Plenary Assembly, which was organised from the 3rd to the 5th of June 2020. During the sessions many soil issues were discussed. In addition, the Commission submitted comments on the '*Protocol for the assessment of sustainable soil management practices*'.

6.6.3. (a) 5th ISEH and (b) 6th ICEPH

The IUGS Commission on Global Geochemical Baselines, the EuroGeoSurveys Geochemistry Expert Group, and the International Association of GeoChemistry planned a session with the title: '*Geochemical mapping at all scales: evidence from soil, sediment, water and plants*'. Due to the Covid-19 pandemic the joint two international conferences (i) 5th International Symposium on Environment and Health (ISEH) and (ii) 6th International Conference on Environmental Pollution and Health (ICEPH), which were planned to be held in Galway (Ireland) from the 2nd to the 9th August 2020, were postponed to August 2022 (http://www.nuigalway.ie/iseh2020/).

6.6.4. World Soil Day 2020 'Keep soil alive, Protect soil biodiversity'

Members of the Commission participated in the virtual webinar '*Keep soil alive, Protect soil biodiversity*' organised by FAO's Global Soil Partnership on the 4th of December 2020 for the celebration of United Nations World Soil Day, which is usually celebrated on the 5th of December of every year.

6.6.5. Launch of the European Union Soil Observatory

Members of the Commission participated in the virtual meeting on the 'Launch of the EU Soil Observatory', which was organised by the Joint Research Centre on the 4th of December 2020.

6.7. MANUAL OF STANDARD METHODS FOR ESTABLISHING THE GLOBAL GRN

The Commission is continuing the work on the compilation of the comprehensive '***International Union of Geological Sciences Manual of Standard Methods for Establishing the Global Geochemical Reference Network***', which started in the first quarter of 2018. The FOREGS 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). As it was mentioned in the 2018 Annual Report, the present manual will be far more extensive and well-illustrated, and the outline was given, as well as the principal authors. 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.

Although the original plan was to complete the manual by the first half of 2019, as stated in the 2018 annual report, many unexpected problems arose, some personal in nature. However, most are due to Geological Survey or University work, which takes precedence, and in one case with respect to the Arctic terrain, our colleague from Chile was unable to go in the field at the planned period, which has been postponed to January 2020, as reported in the Commission's 2019 Annual Report. Finally, the three-member team from the Geological and Mining Survey of Chile went to Tierra del Fuego in March 2020, and submitted its report in October 2020 (see Appendix 4). This report is an important contribution to under preparation Manual.

The chapter that apparently is giving most problems is the Residual Soil Sampling chapter. It has been agreed that the bottom or deep soil sample must be collected from the C horizon because this is the reference horizon. There are problems, however, with the sampling of the topsoil horizon. Problems that are mainly due to the different morpho-climatic environments (Figure 4). Therefore, a consensus was needed to be reached especially by the four soil scientists that are participating in its writing, and the six applied geochemists. It is believed that this consensus was finally reached in the autumn of 2020, and a new version of the Soil Sampling Chapter is presently being revised and will be sent to all co-authors for review in the beginning of 2021.

Finally, the external reviewers are not always available to review Chapters in the time that is usually allocated, *i.e.*, four-weeks.

The title of the Manual is also under discussion. The tentative title, used up to now, is '*International Union of Geological Sciences Manual of Standard Methods for Establishing the Global Geochemical Reference Network*'. Two alternative titles are proposed and will be discussed, namely:

- '*International Union of Geological Sciences Manual of Standard Methods for the Global Geochemical Reference Network and Regional Geochemical Surveys*', and

- '*International Union of Geological Sciences Manual of Standard Methods for Global Geochemical Baselines and Regional Geochemical Surveys*'.

The above two tentative titles are considered more appropriate because the sampling methods and the procedures described can be used in regional geochemical surveys too.

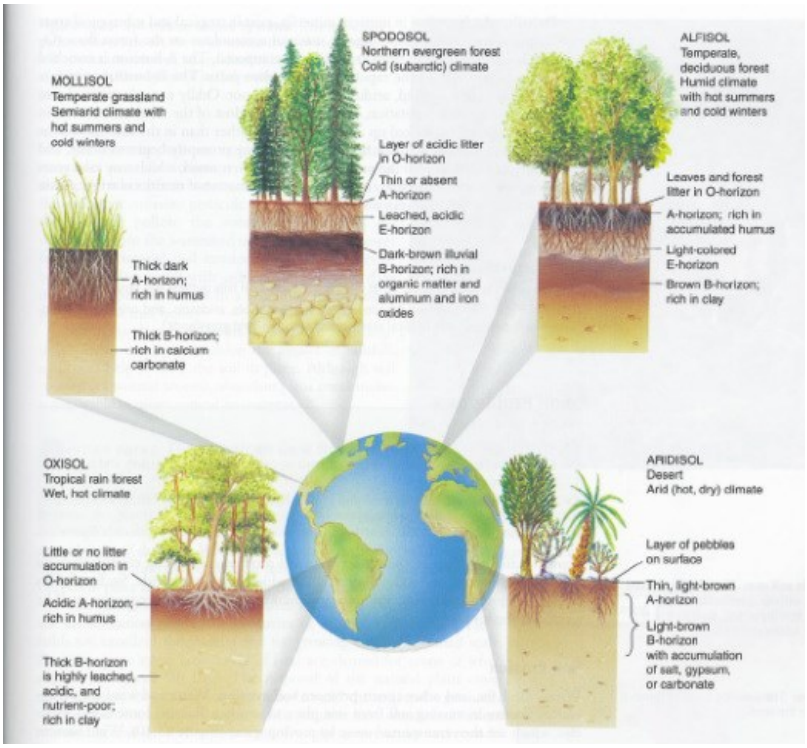


Figure 4. Soil profiles according to climatic zones (Source: https://vssoils.weebly.com/soil-types.html).

Another issue that was discussed, especially during the review of the Chapter on 'Residual soil' sampling was the necessity of the four Special terrain chapters, namely (i) Karst, (ii) Desert & semi-grassland – Savannah, (iii) Tropical – Rain forest, and (iv) Arctic-Antarctic (or Polar and Sub-polar). As the main problem that needed to be tackled in these four special terrain chapters is 'Residual soil' and to a lesser extent 'Stream sediment sampling' in desert terrains, it was finally decided to include additional instructions and information as Annexes in these Chapters.

An effort will be made for the Manual to be completed within 2021, and submitted to the IUGS Executive Committee for approval together with written opinions of two external reviewers for each chapter.

Table 1 shows the progress in the writing of the different Chapters and Sections.

Table 1. Progress in the compilation of the 'International Union of Geological Sciences Manual of Standard Methods for Establishing the Global Geochemical Reference Network'.

Chapter title	***Stage in the writing process***		
Abstract	In progress		
Preface	In progress		
Acknowledgements	In progress		
Chapter 1. General introduction	1st draft		
Chapter 2. GTN grid cells and Selection of sample sites	1st draft		
Chapter 3. Sampling			
3.1. Samples to be collected from <100 km^2 catchment basin (see Figure 5)			
3.1.1. Stream water	Completed	Under review	

Chapter title	*Stage in the writing process*		
3.1.2. Stream sediment	Completed	Under review	
3.1.3. Overbank sediment	Completed	Under review	
3.1.4. Residual soil	Discussed		
3.1.5. Rock	1st draft		
3.2. Samples to be collected from 1000 to 6000 km^2 catchment basin (see Figure 5)			
3.2.1. Floodplain sediment	Completed	Under review	
Chapter 5. Sample preparation	1st draft		
Chapter 6. Preparation of Reference materials for external QC	Completed	Under review	
Chapter 7. Analytical methods	Completed	Under review	
Chapter 8. QC and estimation of measurement uncertainty	Final corrections		
Chapter 9. Data conditioning	Completed	Reviewed	Revised
Chapter 10. Criteria of Global Geochemical Baselines Database	1st draft		
Chapter 11. Data processing and presentation	1st draft		
Appendix 1. World soil profiles	Completed	Under review	
Appendix 2. Quality control script	Completed		
Appendix 3. Five-random sample site generation script	Completed		
Appendix 4. Eight-random sample site generation script	Completed		
Appendix 5. Sixteen-random sample site generation script	Completed		
Appendix 6. Generation of random sample numbers for randomisation of samples	Completed		
Appendix 7. Taking good photographs for sample documentation	Under writing		
Field observation sheets	Completed		

Ideally, all recommended sample media, including parent rocks, should be collected for the establishment of a Geochemical Reference Network of permanent value for the whole terrestrial surface of our home planet Earth for multipurpose and multidisciplinary use (Figures 5 & 6). ***It is stressed that the UNESCO International Centre on Global-Scale Geochemistry is only collecting top and bottom floodplain sediment samples from the large 3rd order rivers, hopefully according to the agreed methodology, discussed and agreed during the October 2018 meeting in Langfang (P.R. China), and which is included in the under compilation IUGS Manual of Standard Methods*** (see Annex 1.1 of Appendix 1). *It is important to note that the UNESCO International Centre on Global-Scale Geochemistry is not following 'Blue Book' specifications, and is also worth studying Section '**6.5.2. Comments on the Agreements**' in the Commission's 2018 Annual Report (p.23-26).*

6.8. GLOBAL BLACK SOIL PROJECT

The Sampling Committee Chair and a member from the Analytical Committee are representing the Commission in the Global Black Soil Critical Zone Geo-ecological Survey (BASGES) project.

6.8.1. IUGS Manual of Standard Geochemical Methods for Global Black Soil Project

The final version of the IUGS Manual of Standard Geochemical Methods for the BASGES project was presented and discussed at the third Workshop, which was organised on the 20th and 21st of November 2019 by the Shenyang Centre of China Geological Survey in Chengdu, the capital of south-western China's Sichuan province (see 2019 Annual Report, p.25-29).

A hard copy and an electronic version of the BASGES manual was submitted to the IUGS EC Secretary General in January 2020 in order to be approved for publication.

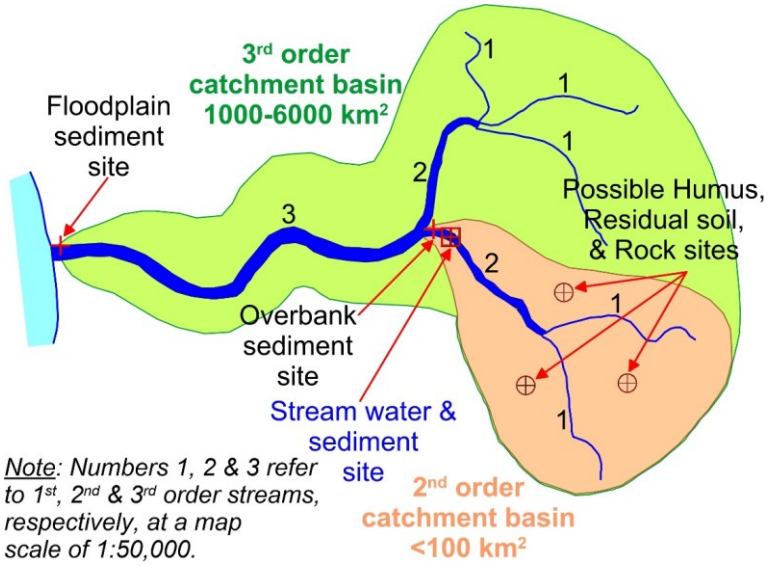


*Figure 5. Diagram showing the recommended sample types to be collected from the random drainage basins within the 160x160 km grid (refer to [2018 IUGS-CGGB Annual Report](), Section 6.8.1, p.31-33). In total 10 samples should be collected, i.e., 8 samples from the small 2nd order catchment basin of <100 km² in area: (i) Humus where possible; (ii) topsoil horizon; (iii) bottom soil from the C horizon, which is considered the reference point (dominant soil type within the small catchment basin); (iv) parent rock (dominant rock type within the small catchment basin); (v) top surface horizon of overbank sediment; (vi) bottom overbank sediment horizon at a depth that is considered pristine; (vii) stream water, and (viii) active stream sediment, and 2 samples from the large 3rd order river of 1000-6000 km² in area, i.e., (ix) top surface horizon of floodplain sediment (**NOT alluvial agricultural soil**), and (x) bottom horizon of floodplain sediment, again from a depth that is considered pristine. Diagram plotted with Golden Software's MapViewer™ v8 by Alecos Demetriades, I.G.M.E. & IUGS-CGGB.*

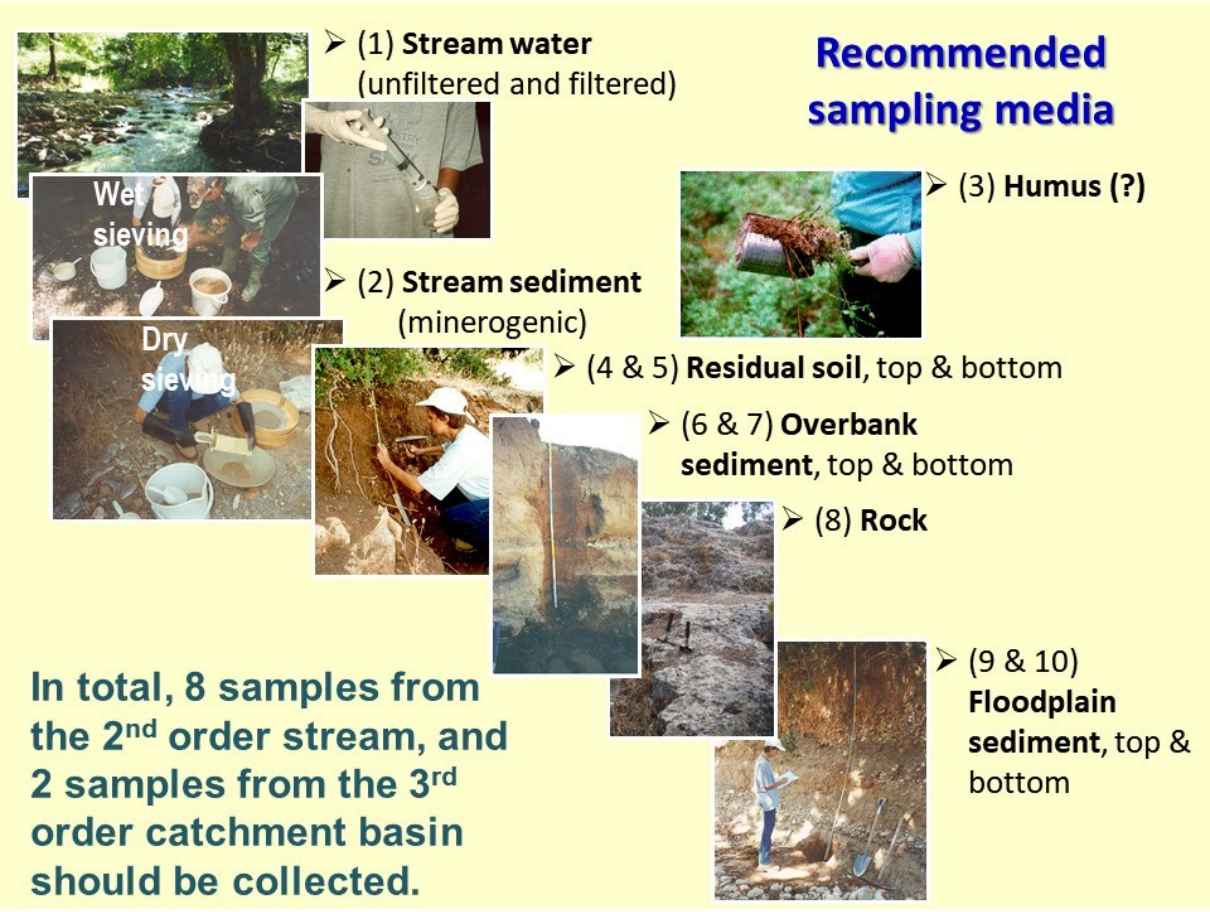


Figure 6. Pictorial diagram showing the recommended sample types to be collected from the random drainage basins within the 160x160 km grid. Photographs: Alecos Demetriades, except Humus by Timo Tarvainen.

The Executive Committee of the International Union of Geological Sciences approved the publication of the '*International Union of Geological Sciences Manual of Standard Geochemical Methods for the Global Black Soil Project*' at its 74th meeting in Busan of South Korea on the 17th of January 2020. The Executive Committee members Qiuming Cheng (President), Kristine Asch (Vice President), William Cavazza (Vice President), Stanley C. Finney (Secretary-General), Hiroshi Kitazato (Treasurer), Roland Oberhänsli (Past President), Ben Mapani (Councillor), Edmund Nickless (Councillor), Silvia Peppoloni (Councillor) and Claudia Mora (Councillor) are thanked for approving the publication of this manual.

Following the approval for publication of the BASGES manual, an application was submitted to the National Library of Greece for the acquisition of an ISBN number, and directly afterwards the manual was uploaded to the Commission's website from where it can be freely downloaded:

Demetriades, A., Dai, H., Liu, K., Savin, I., Birke, M., Johnson, C.C., Argyraki, A. (Editors), 2020. *International Union of Geological Sciences Manual of Standard Geochemical Methods for the Global Black Soil Project*. International Union of Geological Sciences, Commission on Global Geochemical Baselines, Special Publication No. 1, Athens, Hellas, ISBN: 978-618-85049-0-5, 107 pages, 49 figures, 4 Tables, and 4 Appendices (Figure 7).

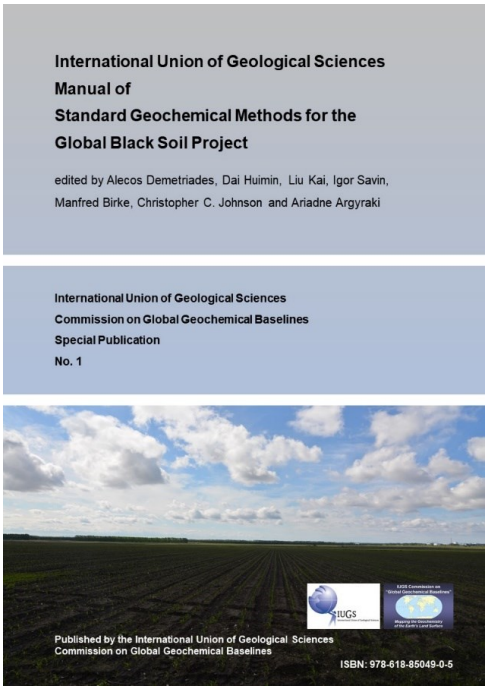


Figure 7. Cover page of the International Union of Geological Sciences Manual of Standard Geochemical Methods for the Global Black Soil Project.

The first obligation of the Commission to the BASGES project is completed with the publication of the '*IUGS Manual of Standard Geochemical Methods for the Global Black Soil Project*'.

6.8.2. Requirements that must be fulfilled by the Shenyang Centre of CGS

The requirements that should be fulfilled before the start of the Global Black Soil project are now in the hands of the Shenyang Centre of China Geological Survey. These were presented and discussed at the 3rd Black Soil Workshop in November 2019 and are:

- Preparation of two large Black Soil project reference samples – Secondary Reference Materials (SRMs);

- Preparation of one large Black Soil project blank reference sample;
- Compilation of a detailed protocol of the analytical methods that will be used for the analysis of the Black Soil project samples;
- Decision where the Global Black Soil project samples are going to be prepared, and permanently stored;
- Decision where the Global Black Soil project samples are going to be analysed, and by which analytical methods and for which determinands;
- Purchase of field and laboratory equipment by the Black Soil Project Management, and distribution to all participating countries, and
- Field training of representatives from each participating country, and start of field sampling campaign with a deadline to be agreed.

Dai Huimin, Director of Global scale geochemistry survey of Black soil regions, informed the Commission's Sampling Committee Chair on the 17th of December 2020 that the two large Black Soil project reference samples (phaeozem and chernozem) for external quality control were collected. Although the laboratory can handle larger samples due to time and cost, they collected about 100 kg of each reference sample, and if necessary, the same sites will be sampled at a future time (the recommendation was to make two reference samples of 1,000 kg each). The two samples were dried at room temperature and sieved to <2 mm. The samples after homogenisation were split into 100 g sub-samples, making about 1000 sub-samples of each reference sample. At present, homogeneity test, stability test and initial value determination are being carried out. Next is the ring test, which is being discussed.

6.9. COMMISSION'S WEBSITE

The Commission's website is updated on a regular basis. On checking the statistics of visits to the website, it was discovered that Google Analytics were not installed on each webpage during the redesigning of the wesbsite in 2018. So, the Web design company was asked to install Google Analytics on each web page, and also to add a pale yellow colour to the dropdown menus in order to be visible. This work was done in October 2020 at no cost.

On the 14th of October 2020 at 20:00 a Skype meeting was organised among Ariadne Argyraki (Public Relations and Finance Chair and Webmaster), Christina Stouraiti (Treasurer and deputy webmaster), and Alecos Demetriades (Advisory Panel member) to discuss the mode operation and updating of the Commission's website.

Figure 8 shows a screen shot of Google Analytics location map of sessions from the 12th of October (day that it became operational) to the 31st of December 2020. The global distribution of the 433 users from 73 countries and 232 cities is quite impressive for the 69 days of operation of Google Analytics. In total, there were 619 sessions.

6.10. WORK OF COMMISSION'S COMMITTEES

6.10.1. Sampling, Analytical & Data Management Committees

During 2020 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 the Global Geochemical Reference Network and Regional Geochemical Surveys'* (see Section §6.7).

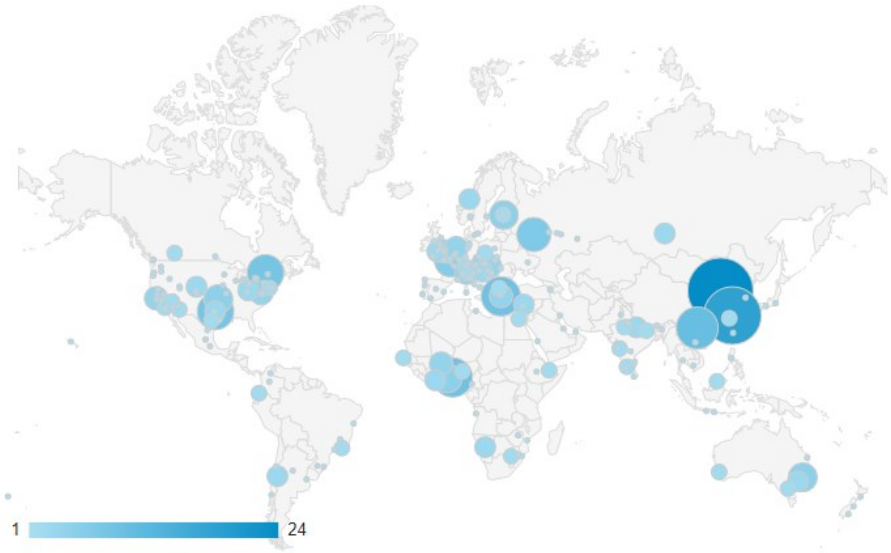


Figure 7. Screen shot of Commission's Google Analytics web page showing visits from different cities from the 12th of October (day Google Analytics was operational) to the 31st of December 2020.

6.10.1.1. Conversion of computer programs to 32- & 64-bit windows platform

During the two-day Workshop on the occasion of the 3rd YES Congress in Dar es Salaam, Tanzania (12-13 August 2014; see 2014 Annual Report, p.25), computer data processing was discussed. The workshop participants, who were mainly from African countries, explained the financial difficulties for the purchase of software. Since, then public domain software is recommended in workshops, such as SAGA GIS (https://sourceforge.net/projects/saga-gis/), and QGIS (http://qgis.org/en/site/). However, these programs do not cover all the statistical work that is normally carried out in applied geochemical surveys. Therefore, the conversion of computer programs used by the Division of Geochemistry and Environment of the Hellenic Institute of Geology and Mineral Exploration was discussed with the in-house computer programmer, Evripides Vassiliades. To convert Fortran IV programs to work on 32- and 64-bit windows platform, the SimplyFortran software program was required. Following its purchase, two programs that have been converted are (i) 'Merge', and (ii) 'ROBCOOP4', and are currently being tested by students at the Department of Geology and Geoenvironment of the National and Kapodistrian University of Athens (Hellenic Republic).

Program 'Merge' combines two files by using the same identification code, *e.g.*, (a) file with sample number and site coordinates with (b) file with analytical data. Program 'ROBCOOP4' by Ramsey (1998) uses robust balanced analysis of variance (RANOVA) to estimate the total measurement uncertainty and also to quantify the contributions to that uncertainty which arise from the processes of primary sampling and chemical analysis, the sampling and analytical variance, respectively. This is a useful program for testing the quality of analytical data. A number of programs from Davis (1973) are in the process of conversion. All programs with instructions and their source codes will be made freely available from the Commission's website directly after the publication of the '*International Union of Geological Sciences Manual of Standard Methods for Establishing the Global Geochemical Reference Network'.*

6.10.2. Public Relations and Finance Committee

The Public Relations and Finance Committee's main work was the updating of the Commission's website in collaboration with the web hosting company where necessary. For example, some files for downloading cannot be uploaded by the Commission's webmaster. In the work schedule is included still the exploitation of a few options for obtaining sponsorships.

However, due to the Covid-19 pandemic, and the problems caused to many potential sponsors this work was postponed to better future times.

The Public Relations and Finance Committee also informed all Commission members about webinars and conferences of interest, namely:

- 10th of July 2020: '*The National Virtual Core Library (NVCL) - Building a continental-scale drill core database*' organised by CSIRO Australia. The webinar is available from YouTube at: https://youtu.be/AlcIqAGc9U4.
- 17th & 19th November 2020: '*Responding to societal needs with 3D geology: An international perspective*' organised by the Geological Survey of Canada, Illinois State Geological Survey, British Geological Survey, Alberta Geological Survey, Minnesota Geological Survey, and Geological Survey of the Netherlands (TNO). The webinar is available from YouTube at: https://youtu.be/euvo6TwjAFA. Read the 'World Community of Geological Surveys' (WCOGS) newsletter at: http://www.eurogeosurveys.org/wp-content/uploads/2020/11/WCOGS_Newsletter.pdf.
- 4th December 2020: '*World Soil Day*' organised by the Global Soil Partnership of the UN Food and Agricultural Organisation. Key presentations and videos have been uploaded to YouTube, and these are:
  - World Soil Day – 5 December 2020: https://youtu.be/puOqDPL_BME.
  - World Soil Day – 5 December 2020: https://youtu.be/_bZ_lLTT-Jk.
  - World Soil Day: https://youtu.be/4kzmAfou9G4.
  - World Soil Day 2020 | Themes of World Soil Day 2014-2018 | 5 December 2020: https://youtu.be/jL2wXJaJZ0s.
  - World Soil Day 2020: https://youtu.be/e9VYmj9nH1w.
  - World Soil Day 2020: https://youtu.be/Ok0bumPwnkY.
  - Happy Soil Day – World Soil Day 2020 Best Video – 5th December 2020: https://youtu.be/6j-uxxd5BJw.
  - Keep soil alive, protect soil biodiversity: https://youtu.be/hbdsHOnd_gw.
  - Beneath our feet – World Soil Day 2020: https://youtu.be/ZKSoTlmYMS8.
  - World Soil Day 2020 4p1000 Initiative: https://youtu.be/uGc0kI8FgBw.
  - World Soil Day 2020 – Celebrating Harvests: https://youtu.be/W5ryZY1O9fA.
  - Thailand Today2021 EP37: World Soil Day 2020: Keep Soil Alive, Protect Soil Biodiversity: https://youtu.be/7_bBmG4pfoI.
  - King Bhumibol World Soil Day Award – Edition 2020: https://youtu.be/2AhCmzlV1PU.
  - Our message on World Soil Day 2020: https://youtu.be/2yCWsF7rM6A.
- 9th December 2020: '*Introduction to Forensic Geology/Petrography*' organised by the American Institute of Professional Geologists and the American Geosciences Institute according to their initiative 'Geoscience Online Learning Initiative (GOLI)'. The webinar is available from YouTube at: https://youtu.be/mG-2umlCvN8.
- 29th December 2020: '*UNESCO Lecture Series: Earth Materials for a Sustainable and Thriving Society*' in collaboration with IUGS and iCRAG. Dates: 26 January 2021 to 1 April 2021; https://www.iugs.org/unesco-lectures.

Constant updates of all Commission's activities as well as links to related topics of other organisations are also uploaded on the social media pages of CGGB (Twitter: @CGGB_IUGS and Facebook: @CGGBIUGS). A steady increase of follower numbers is noticed for 2020, reaching 102 followers in Twitter and 464 followers in Facebook.

6.11. ASSISTANCE TO MEMBERS AND WORKSHOP PARTICIPANTS

6.11.1. Evaluation of questionable sampling and recommendation

The Commission's Sampling Committee Chair was contacted by a country on a confidential basis to check the quality of sampling that was carried out under the contract with China Geological Survey and the UNESCO International Centre on Global-Scale Geochemistry. The two Chinese institutions were responsible for training and supervision of sampling. The Commission's Sampling Committee Chair asked the country's contact to send him (i) photographs of the sampling sites, (ii) the field observation sheets, and (iii) a map with the sample locations. Only items (i) and (iii) were sent.

After examining the material sent, the first comment was that the person or persons that collected the samples were definitely not trained properly, and the sampling is extremely questionable, *i.e.*, top and bottom overbank sediments and soil samples were taken from sloping ground by just digging small pits on the top and bottom of the slope (see Figures 8 and 9). The recommended procedure is to dig a single pit to expose the whole vertical profile in order to see the overbank sediment layers and soil horizons, respectively. In one case, there was an extremely good exposure of a riverbank section of overbank sediments, and the sampler has taken the top and bottom samples with this odd method as shown in Figure 8. In another case, the sample number label was for soil, and the sample type was overbank sediment, according to the photographic documentation. Finally, samples were taken directly below high power electric lines, which is not allowed. Therefore, to cut the long story short, the whole sampling campaign in this particular country is questionable. The recommendation was that an experienced applied geochemist must study all photographs, maps of sampling sites, and the field observations sheets in order to decide which samples can be used, a job that is not easy.

Figure 8. 'Bad overbank sediment sampling'. The instructions are to collect top and bottom overbank sediment samples from the surficial and deepest accessible layers after studying the exposed section by either digging a pit in the floodplain or clearing a riverbank section. Question: Are the collected samples, as shown in the photograph, acceptable? Answer: The two samples are unacceptable and should be thrown away. It is quite apparent from this photograph that the samplers were not well-trained, and there was also no strict supervision.

Figure 9. 'Bad residual soil sampling'. The instructions are to collect top and bottom residual soil samples from the surficial A and deeper C horizons after studying the exposed profile by digging a pit. Question: Are the collected samples as shown in the photograph acceptable? Answer: The two samples are unacceptable and should be thrown away. Again, it is quite apparent from this photograph that the samplers were not well-trained, and there was also no strict supervision.

This '*bad sampling*' practice is not a surprise to the Chair of the Commission's Sampling Committee, as he has been in the field with Chinese applied geochemists from the UNESCO International Centre on Global-Scale Geochemistry. It is worth consulting the Commission's 2017 Annual Report (p.35-42 and p.65-70), where such '*bad sampling procedures*' are discussed.

As '*sampling*' and '*sample preparation*' are two key procedures in any geochemical survey, they must be carried out by well-trained personnel, and supervised by experienced applied field and laboratory geochemists. The PowerPoint slide displayed in Figure 10 is always shown in all training workshops organised in China in collaboration with China Geological Survey (CGS) and Institute of Geophysics and Geochemistry (IGGE):

(i) Seminar on '*CCOP Geochemical Mapping*', 28-29 March 2012, Nanjing, P.R. China;
(ii) '*CGS-CCOP-ASEAN-IUGS/IAGC Workshop on Geochemical Mapping*', 3-8 September 2013, Nanning, Guangxi, P.R. China;

and, subsequently, with the UNESCO International Centre on Global-Scale Geochemistry:

(iii) Workshop on '*Geochemical Mapping for 'Belt and Road' countries*', 23-30 September 2017, Langfang, P.R. China

Further, it is strongly recommended to consult the following two publications:

Demetriades, A., 2014. *Basic considerations: Sampling, the key for a successful applied geochemical survey for mineral exploration and environmental purposes*. Chapter 15.1 In: W. F. McDonough (volume Editor), Analytical geochemistry/Inorganic instrument analysis. In: H.D. Holland & K.K. Turekian (Executive Editors), Treatise on Geochemistry. Elsevier, Oxford, vol. 15, 1-31; https://doi.org/10.1016/B978-0-08-095975-7.01401-7.

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.B. (Guest Editor), Geochemical Mapping. Special Issue, Geochimica Brasiliensis, 32(2), 136-179; http://doi.org/10.21715/GB2358-2812.2018322136.

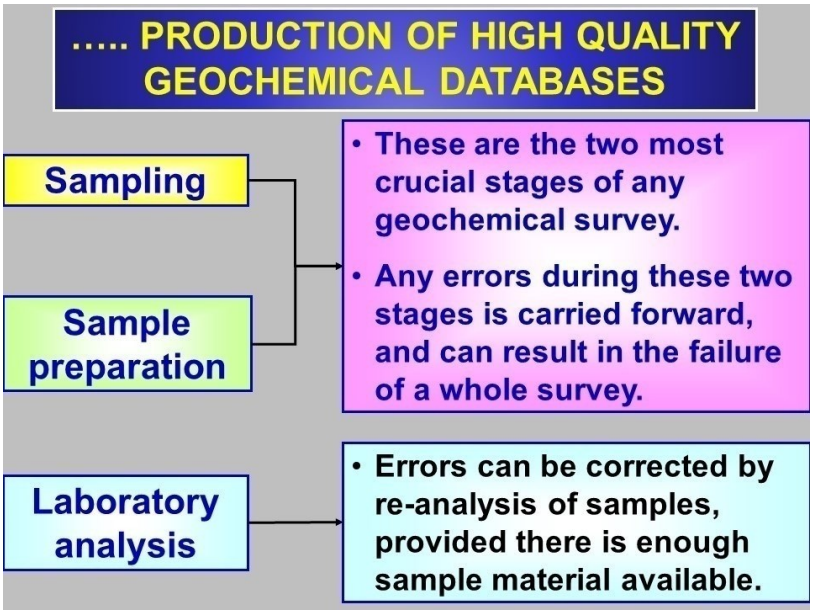


Figure 10. PowerPoint slide from applied geochemistry training Workshop.

6.11.2. Assistance to members and workshop participants

This year due to the Covid-19 pandemic there were no requests for assistance by Commission members and workshop participants.

6.12. PUBLICATIONS

Publications directly related to the Global Geochemical Baselines project were not published this year. However, there are publications for the continental-, regional and local scale projects carried out in different continents. These will be found in Appendix 5: Regional Reports.

The Commission sent a two-page report about the publication of the *International Union of Geological Sciences Manual of Standard Geochemical Methods for the Global Black Soil Project*, which was published in the IUGS-E-bulletin No. 171 in November 2020.

7. REGIONAL REPORTS

Regional reports were provided from Africa, Central America (Mexico), North America (United States of America), South America (Brazil, Chile, Colombia), Asia (Armenia, China, India, Japan), Australasia (Australia and New Zealand), and Europe (EuroGeoSurveys Geochemistry Expert Group, Cyprus, Sweden and United Kigdom). These reports are in Appendix 5: Regional Reports. An important contribution to the '*IUGS Manual of Standard Methods for Global Geochemical Baselines and Regional Surveys*' is the Reconnaissance Survey in a sub-antarctic environment carried out on Tierra del Fuego in Chile (see Appendix 4).

8. NEW MEMBERS

In 2020, the Commission made 19 new members from China (3), Cyprus (1), Ecuador (2), Estonia (1), Honduras (1), Ireland (1), Mexico (2), Peru (1), Saudi Arabia (2), South Africa (1)

and Spain (4). In total, the Commission has 180 members in 71 countries (see Members list in Commission's web page, and their countries are shown in Figure 11.

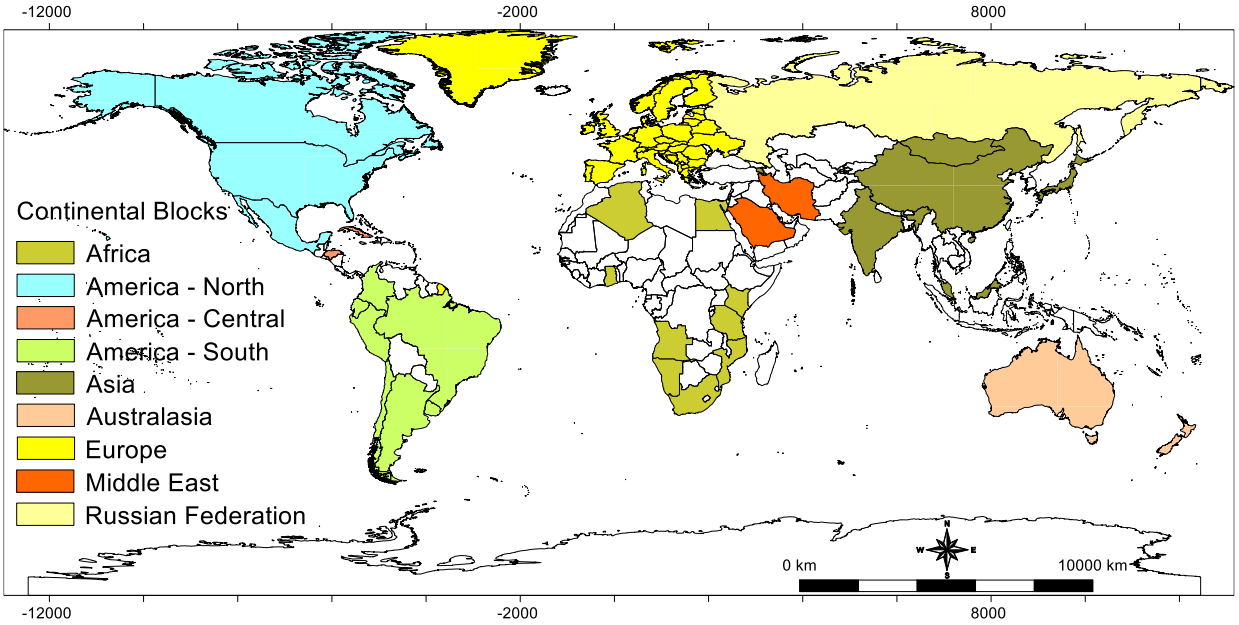


Figure 11. Map showing countries with Commission members. The different colours represent continental blocks. The Russian Federation has its own colour because it is in two continental blocks, Europe and Asia. Map plotted with Golden Software's MapViewer™ v8 by Alecos Demetriades, I.G.M.E. & IUGS-CGGB.

9. IUGS FUNDING FROM 2013 TO 2020

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; US$4000 for 2018; US$4000 was the annual allocation for 2019. Additional amounts of (i) US$3500 was allocated for the two-day Workshop organised on the occasion of the 5th YES Congress in Berlin in September 2019, and (ii) US$3200 for the 36th IGC in Delhi in March 2020, and US$2800 was the 2020 allocation.

10. USAGE OF IUGS 2020 ALLOCATION

Usage of allocated 2020 fund of US$2,800 and outstanding 2019 balance of US$1,414.77, making an overall total of **US$4,214.77** is shown in Table 2.

It should be noted that most of the expenses for participation in the:

(i) 74th IUGS EC meeting in Busan of South Korea in January 2020 amounting to US$1,179.29, and
(ii) 36th IGC in New Delhi totalling US$2,567.05

were paid in 2019 (see Table 4 on p.34 in the 2019 Annual Report). The only expense that was paid in 2020 for the 36th IGC was the visa fee for entry in India (Table 2).

The postponement of the 36th IGC in Delhi resulted in the loss of funds, *i.e.*,

- Registration fees paid were US$521.32, and the refund was US$398.49, *a loss of US$122.83*.
- Return airline fee Athens-New Delhi-Athens was US$1,179.29, and the refund was US$882.29, *a loss of US$297.00*.

- Hotel booking and transfer from and to airport, and from hotel to venue through the 36th IGC desk was *US$1,120.30*. This amount has not been refunded yet, and should be considered lost.
- India visa cost was *US$80.00, which is lost.*

The total amount lost from the cancellation of the 36th IGC due to Covid-19 is: *US$1,620.30*.

The outstanding balance in the Commission's bank account at the end of 2020 is US$**4,583.13**.

Table 2. Expenses incurred during 2020.

Expenses incurred	US$
Bank charges on the transfer of the IUGS 2020 allocation	3.89
Reporting by Commission Treasurer at 74th IUGS EC meeting, Busan, South Korea (15-16/1/2020). Various expenses (printing of Black Soil Manual for EC, hotel, travel insurance, local travel, snacks at airports) – see Section §6.1.	534.73
Cost for the issue of visa for entry in India for the 36th IGC	80.00
Cost of production of 10 CD's, purchase of CD cases, and printing of CD labels for the '*International Union of Geological Sciences Manual of Standard Geochemical Methods for the Global Black Soil Project*' (two copies submitted to the National Library of Greece for the issue of the ISBN number, and others will be given to the co-authors) – see Section §6.8.1	14.14
Annual Commission's website hosting fee and domain renewal (2020-2021)	289.73
Bank charges on the transfer of the Annual website hosting fee & domain renewal	2.84
Total 2020 expenses:	**925.33**

11. FUNDING REQUEST FROM IUGS FOR 2021-2022

11.1. PLANNED 2021 ACTIVITIES REQUIRING NO FUNDS

The main Commission activities in 2021 that require no funds are:

(i) Completion of the '*International Union of Geological Sciences Manual of Standard Methods for the Global Geochemical Reference Network and Regional Geochemical Surveys*', which is planned to be completed in 2021, subject to the voluntary input by all the people that are involved in this especially important reference work for global and regional geochemical surveys (see Section §6.7). The in-kind engagement includes both authors and reviewers.

(ii) 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 (see Section §6.10.1.1);

(iii) Preparation of conference presentations (*e.g.*, Goldschmidt2021), and workshop material;

(iv) Preparation of Periodic Table Element maps of the Geochemical Atlas of Europe for stream water, stream sediment, subsoil and floodplain sediment for the printing of large-size posters for promotion of the Global Geochemical Baselines project;

(v) Updating the Commission's website;

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

(vii) Revision of the IGCP 259 Report, the 'Blue Book' (Darnley *et al.*, 1995) by removing all contradictory parts [will start directly after the completion of item (i)], and

(viii) Starting the compilation of a popular well-illustrated book for lobbying at the United Nations and UNESCO level for all 196 Member States to agree to carry out the project as will be detailed in the IUGS Manual of Standard Methods. This activity is in-line with the objective '*to increase the awareness of policy and decision makers of the need for harmonised geochemical data at the global scale*.' The promotion of the Global Geochemical project is an activity that will be carried out beyond 2021.

Although no funds are requested for the above work, it should be stressed that they are funded by Commission member Geological Surveys and Universities. Hence, it is considered important that a conservative estimate of person-months should be made. It is estimated that all colleagues from all over the world contributing to the above work is about 30 person-months.

11.2. PLANNED 2021-2022 ACTIVITIES REQUIRING IUGS FUNDING

As the World is still in uncharted waters with respect to the Covid-19 pandemic, and the waiting for the vaccination of 70% of the population to achieve immunity, we are a little conservative with respect to any activities that need personal contact until the end of August 2021.

The following planned activities in 2021, and first quarter of 2022, require IUGS funding:

- Sandblasting of painted sampling equipment for photographs to be included in the '*International Union of Geological Sciences Manual of Standard Methods for the Global Geochemical Reference Network and Regional Geochemical Surveys*' – See Section §6.7.
- Participation in the Goldschmidt 2021 conference, 4-9 July 2021, Lyon, France. Session: '*Geochemical mapping at all scales for all reasons*' under Theme 12: '*Environmental Geochemistry and Human Health*'. This session is jointly organised by the Commission and the EuroGeoSurveys Geochemistry Expert Group.
- Organisation of webinars for up to 300 participants using Zoom. We have the material to organise two- to three-day webinars. The first will use the YES Workshop material. Organising webinars will be an important activity after the publication of the '*International Union of Geological Sciences Manual of Standard Methods for the Global Geochemical Reference Network and Regional Geochemical Surveys*' (see Section §6.7). This activity requires the purchase of a one-year licence of the Zoom platform for virtual meetings and workshops (webinars).
- Organisation of the three-day autumn annual joint business meeting of the Commission and the EuroGeoSurveys Geochemistry Expert Group, which is planned for the 4th, 5th and 6th of November 2021 in Athens (Hellas). The Commission will jointly host the meeting with the Hellenic Institute of Geology and Mineral Exploration.
- Production of CD's for the '*International Union of Geological Sciences Manual of Standard Methods for the Global Geochemical Reference Network and Regional Geochemical Surveys*' (two copies of the e-book are required to be submitted to the National Library of Greece for the issue of the ISBN number).
- Participation in the 4th BASGES Workshop organised by the Shenyang Centre of China Geological Survey in the autumn of 2021.
- Printing of remaining posters on canvas of the Periodic Table of mapped elements of the Geochemical Atlas of Europe for stream water, stream sediment, subsoil and floodplain sediment for promotion of the Global Geochemical Baselines project (see Appendix 6).

- Web-hosting annual fee and domain renewal (2021-2022) of the Commission's website, and
- Participation in the 76th IUGS Executive Committee meeting in January/February 2022 at a place to be decided by the IUGS Executive Committee.

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

- US$4,000 for the 2021 planned work and commitments (Table 3), and
- US$2,000 for the first quarter of 2022 to cover the expenses for its participation in the 75th IUGS Executive Committee meeting (Table 3).

Thus, making a total request of **US$6,000** for 2021 and first quarter of 2022.

It should be mentioned that in the 2021 budget (Table 3), the cost of US$30,000 for the organisation of training workshops for CCOP countries recommended in the 2019 ARC report is not included, as this depends on the availability of funds from IUGS, and because of the Covid-19 pandemic is unlikely to plan any physical workshops during 2021. Nevertheless, if such an amount is made available, it should not be restricted to CCOP countries, but it should include African and Latin American countries.

Table 3. Estimated expenses for 2021 and first quarter of 2022.

Event category	Cost in US$
Sandblasting of painted sampling equipment for photographs to be included in the '*International Union of Geological Sciences Manual of Standard Methods for the Global Geochemical Reference Network and Regional Geochemical Surveys*' (see Section §6.7)	100.00
Participation in the Goldschmidt 2021 conference, 4-9 July 2021, Lyon, France. Session: '*Geochemical mapping at all scales for all reasons*' under Theme 12: 'Environmental Geochemistry and Human Health'. This session is jointly organised by the Commission and the EuroGeoSurveys Geochemistry Expert Group	2,000.00
Organisation of webinars for up to 300 participants using Zoom. We have the material to organise two to three days webinars. The first is to use the YES Workshop material. Purchase of a one-year Zoom licence	500.00
Organisation of the three-day autumn annual joint business meeting of the Commission and the EuroGeoSurveys Geochemistry Expert Group, which is planned for the 4th, 5th and 6th of November 2021 in Athens (Hellas). The amount includes organisation expenses and providing financial support to members of the Steering Committee	5,000.00
Production of CD's for the '*International Union of Geological Sciences Manual of Standard Methods for the Global Geochemical Reference Network and Regional Geochemical Surveys*' (two copies will be submitted to the National Library of Greece for the issue of the ISBN number) – see Section §6.7.	20.00
Participation in the 4th BASGES Workshop organised by the Shenyang Centre of China Geological Survey in the autumn of 2021. Costs: Travel insurance, local travel to and from airport	250.00
Printing of remaining posters on canvas of the Periodic Table of mapped elements of the Geochemical Atlas of Europe for stream water, stream sediment, subsoil and floodplain sediment for promotion of the Global Geochemical Baselines project (see Appendix 6)	300.00
Annual Commission's website hosting fee and domain renewal (2021-2022) and additional space on server	600.00
Participation in the 76th IUGS Executive Committee meeting in January/February 2022 at a place to be decided by the IUGS Executive Committee	2,000.00
Total estimated expenses in US$ for 2021-22:	**10,770.00**
Outstanding balance (US$) in Commission's bank account at the end of 2020:	**4,583.13**

Estimated minimum amount required to cover 2021-22 expenses, as well as unforeseen expenses is in the region of about **US$6,000**.

11.2.1. Development of analytical reference materials

An important activity is the development of analytical reference materials. All IUGS Commissions are charged to set standards for their geoscientific discipline. Therefore, the Commission is mandated to set standards in geochemical mapping. This important work will be completed with the publication in 2021 of the '*International Union of Geological Sciences Manual of Standard Methods for the Global Geochemical Reference Network and Regional Geochemical Surveys*'. However, the global project, as envisaged by Darnley *et al*. (1995) in the 'Blue Book', cannot start without the development of large reference materials of at least one tonne each for all the sampling types that will be collected, *i.e.*, stream sediment, overbank/floodplain sediment, residual soil, and rock. As IUGS is the global geoscientific body that sets standards in geosciences, it is appropriate to start the development of analytical reference materials. The Commission has the expertise and the laboratory that can make these reference materials, and we ask the IUGS EC to consider the preparation of analytical reference materials.

11.2.2. IUGS Annual allocation to cover first six months of following fiscal year

The Commission enjoyed a sort of freedom in the planning of its work and commitments until 2017, because it was able to accumulate slowly a reserve fund, which at the end of 2017 totalled about US$10,289. The insistence of an EC Councillor to use this reserve fund for RFG2018 resulted at the end of 2018 the outstanding balance to be at US$858.

Without any reserve funds, it is difficult to plan activities and make commitments for the following fiscal year, and especially the first six months, because the annual allocation is usually made available round about April or May of the calendar year. Therefore, it is proposed that the IUGS funding should cover the first six months of the following fiscal year. This is another proposal that the IUGS EC is asked to consider.

12. 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-/.

13. DETAILS OF ANNUAL REPORT AUTHORS

Anna Ladenberger, 1st Co-chair
Postal address: Geological Survey of Sweden, Box 670, SE-751 28 Uppsala, Sweden
E-mail address: anna.ladenberger@sgu.se

Kate V. Knights, 2nd Co-chair
Postal address: Consultant, Dublin, Ireland
E-mail address: kknights@hotmail.com

Gloria Prieto, 1st Deputy-chair
Postal address: Servicio Geológico Colombiano, Diagonal 53 No. 34-53, Bogotá D.C., 11121, Colombia
E-mail address: gprieto@sgc.gov.co

Gloria Namwi Simubali, 2nd Deputy-chair
Postal address: Geological Survey of Namibia, Ministry of Mines and Energy, Private Bag 13297, 6 Aviation Road, Windhoek, Namibia

E-mail address: Gloria.Simubali@mme.gov.na; namwig@gmail.com

Paula Adánez, Scientific Secretary
Postal address: Instituto Geológico y Minero de España, Rios Rosas, 23, CP 28003, Madrid, Spain
E-mail address: p.adanez@igme.es

Christina Stouraiti, Treasurer
Postal address: Department of Geology and Geoenvironment, National & Kapodistrian University of Athens, Panepistimiopolis Zographou, 15784 Athens, Greece
E-mail address: chstouraiti@geol.uoa.gr

Ariadne Argyraki, Public Relations and Finance
Postal address: Department of Geology and Geoenvironment, National & Kapodistrian University of Athens, Panepistimiopolis Zographou, 15784 Athens, Greece
E-mail address: argyraki@geol.uoa.gr

David B. Smith, Advisory Panel
Postal address: US Geological Survey, Denver Federal Center Box 25046, MS 973 Denver, CO 80225, United States of America
E-mail address: dbsmith13@gmail.com

Patrice de Caritat, Advisory Panel
Postal address: Geoscience Australia, GPO Box 378, Canberra ACT 2601, Australia
E-mail address: Patrice.deCaritat@ga.gov.au

Alecos Demetriades, Advisory Panel
Postal address: P.O. Box 640 47 Zografou, GR-157 10, Athens, Hellas
E-mail: alecos.demetriades@gmail.com

REFERENCES

Darnley, A.G., Björklund, A., Bølviken, B., Gustavsson, N., Koval, P.V., Plant, J.A., Steenfelt, A., Tauchid, M., Xuejing, Xie., Garrett, R.G. & Hall, G.E.M., 1995. *A Global Geochemical Database for Environmental and Resource Management. Recommendations for International Geochemical Mapping – Final Report of IGCP Project 259*. Earth Science Report 19. UNESCO Publishing, Paris, 122 pp.; http://globalgeochemicalbaselines.eu.176-31-41-129.hs-servers.gr/datafiles/file/Blue_Book_GGD_IGCP259.pdf.

Davis, J.C., 1973. *Statistics and Data Analysis in Geology*. John Wiley & Sons, Inc., N.Y., 550 pp.

Ramsey, M.H., 1998. *Sampling as a source of measurement uncertainty: Techniques for quantification and comparison with analytical sources*. Journal Analytical Atomic Spectrometry 13, 97–104. Article and software ROBCOOP4.EXE available online at http://pubs.rsc.org/en/Content/ArticleLanding/1998/JA/a706815h; http://dx.doi.org/10.1039/A706815H; ROBCOOP4.EXE: http://pubs.rsc.org/en/Content/ArticleLanding/1998/JA/a706815h#!divAbstract.

Salminen, R., Tarvainen, T., Demetriades, A., Duris, M., Fordyce, F.M., Gregorauskiene, V., Kahelin, H., Kivisilla, J., Klaver, G., Klein, P., Larson, J.O., Lis, J., Locutura, J., Marsina, K., Mjartanova, H., Mouvet, C., O'Connor, P., Odor, L., Ottonello, G., Paukola, T., Plant, J.A., Reimann, C., Schermann, O., Siewers, U., Steenfelt, A., Van Der Sluys, J. & Williams, L., 1998. *FOREGS Geochemical Mapping Field Manual*. Geological Survey of Finland, Espoo, Guide 47, 36 pp.; http://tupa.gtk.fi/julkaisu/opas/op_047.pdf.

APPENDIX 1: MINUTES OF VIRTUAL MEETING, 25 JUNE 2020

Time: 15:00 London

Present:
David Smith (DS)
Xueqiu Wang (XW)
Patrice de Caritat (PdC)
Alecos Demetriades (AD)
Anna Ladenberger (AL)
Katherine Knights (KK)
Gloria Prieto Rincón (GPR)
Gloria Namwi Simubali (GNS)
Christina Stouraiti (CS)
Paula Adánez Sanjuan (PAS)
Ariadne Argyraki (AA)
(11 participants)

Agenda

I. Call to order and introduction of participants (DS)
II. Publication of Black Soil manual, and update on the project (AD)
III. Update on progress of IUGS sampling manual; publication plans (AD)
IV. Website update; procedure for making revisions/additions to website (AD)
V. Relationship of IUGS Commission with International Association of Geochemistry (IAGC) (DS)
VI. Relationship of Commission with the Young Earth Scientists Network (AD)
VII. Relationship with FAO's Global Soil Partnership (AD)
VIII. Relationship with the IUGS Initiatives on (a) Forensic Geology and (b) GeoMORE (AD)
IX. Participation in Association of Applied Geochemists (AAG) effort to update '*Practical*
X. *Problems in Exploration Geochemistry*' by Levinson, Bradshaw, and Thomson (1987). For non-AAG members it is possible to download the first chapter from the AAG website (https://www.appliedgeochemists.org/images/stories/Book_PracticalProblemsinGeochemistry/Practical%20Problems%20in%20Exploration%20Geochemistry02_Part%20AReconnaissance%20Surveys.pdf) (DS)
XI. Update on 36IGC in India and the Arthur Darnley Symposium (DS & AD)
XII. Update on IUGS Council meeting (AD)
XIII. Plans after the publication of the two sampling manuals, *e.g.*, revision of 'Blue Book' and writing a popular document for the United Nations General Assembly (AD)
XIV. Update on activities of the UNESCO International Centre on Global-scale Geochemistry (XW)
XV. Other issues
XVI. Adjournment (DS)

I. Call to order and introduction of participants (DS and all participants)

DS: Call to order and welcome
Introductions: who, where, role in Commission and newcomers

SEE AT THE END NOTES SENT by XW and COMMENTS by AD

II. Publication of Black Soil manual, and update on the project (AD)

AD: The IUGS Manual of Standard Methods for the Global Geochemical Mapping was completed and submitted to IUGS Executive Committee for approving its publication at the 74th EC meeting in Busan last January. The EC approved its publication. What is required now is the acquisition of an ISBN number. Because of the lockdown due to Covid-19 pandemic this is delayed because the application will be submitted to the National Library of Greece. Regarding the acquisition of a DOI number, this is not so simple as it is required to pay an annual fee. So, we have to be satisfied with just the ISBN number.

III. Update on progress of IUGS sampling manual; publication plans (AD)

AD: IUGS Manual of Standard Methods for GGB: Very slow progress; Chapter writers have other Geological Survey jobs and can't keep deadlines. Chilean colleague went to Tierra del Fuego (sub-Arctic environment) and has to write methods up. Aim to complete the 1st version of the Manual by end of the year, of course, subject to the colleagues' time availability for work on the Chapters they are responsible. The most difficult chapter is the Chapter on '*Residual soil sampling*', as this depends on reaching consensus on how to sample especially topsoil in all the morphoclimatic environments from Arctic or Polar to Desert.

IV. Website update; procedure for making revisions/additions to website (AD)

AD: The website is updated on a regular basis.
DS: How do we update the website?
AA: Can implement updates; has been shown how to do it; also, Twitter account, which has been a bit quiet lately.
KK: Important updates are relevant, not just frequency; learnings from AAG; worth putting a bit of money into this.

V. Relationship of IUGS Commission with International Association of Geochemistry (IAGC) (DS)

DS: We started as a Task Group in 1998 under both IUGS and IAGC. Since, 2016 we are a Commission under IUGS and still a Task Group under IAGC, actually a Working Group. We are different from other IAGC Working Groups who have their own conferences and publications. IAGC is happy with this arrangement and understands our Common marches to the beat of IUGS and not IAGC's.

VI. Relationship of Commission with the Young Earth Scientists Network (AD)

AD: For the past 6 years we have been associated with YES. We have organised workshops on the occasion of their international conferences, *e.g.*, Dar es Salaam in Tanzania, Tehran in Iran and Berlin in Germany. The last one in Berlin was in September of 2019, and we organised it together with Ariadne. We were pleased with the two-day Workshop, as there was quite a good interaction with the attendees. In my opinion, we should continue our cooperation with YES as this is the next generation of earth scientists. Ariadne has already been involved. The YES leadership is presently unclear. There were discussions in Berlin, and we understand that there was an election, but we do not yet know the outcome. We should wait and see if they want to continue their association with us.
KK: Is YES associated with IUGS?

AD: It is an Affiliated organisation, and receives some funding from IUGS, but is more or less independent. IUGS financed our participation for the two-day workshop on the occasion of the YES conference in Berlin last September.

VII. Relationship with FAO's Global Soil Partnership - GSP (AD)

AD: EGS-GEG is member of GSP. Recently, they organised a large Zoom meeting with hundreds of people from all over the World.
KK: I have also dealt with them.
AD: Should we become officially affiliated? New leadership should deliberate this.

VIII. Relationship with the IUGS Initiatives on (a) Forensic Geology and (b) GEOMORE (AD)

AD: During the Busan Meeting, the IUGS Forensic Geology is apparently interested in soil, and may possibly like to contribute a section to our Manual. GeoMORE is about the oceans (Christine Ash from BGR is leading it). Interested to extend the global sampling network from continents to oceans. Our Canadian soil scientist colleagues will run the routines and generate the 5 and 8 random sites from the Google Earth kml files.
KK: Who has the expertise in that kind of sampling?
AD: We certainly do not have the expertise in the marine environment. However, we can collaborate with people that have the expertise if we consider this is an important activity to extend our expertise from the terrestrial part in the marine realm.

IX. Participation in Association of Applied Geochemists (AAG) effort to update '*Practical Problems in Exploration Geochemistry*' by Levinson, Bradshaw, and Thomson (1987). AAG members can download the entire book for free from the members section of the AAG website. For non-AAG members, it is possible to download the first chapter at no cost from the AAG website:
(https://www.appliedgeochemists.org/images/stories/Book_PracticalProblemsinGeochemistry/Practical%20Problems%20in%20Exploration%20Geochemistry02_Part%20AReconnaissance%20Surveys.pdf) **(DS)**

DS: Effort here is more to develop online learning modules after the book. Problems to be tackled in book range from simple to more complex, set the scene then ask questions and answers. You, your organisation or the CGGB might want to consider participating into this online teaching initiative. CGGB is formally affiliated with AAG, we have an MoU since a few years ago (mutual support, joint symposia, *etc.*).

X. Update on 36IGC in India and the Arthur Darnley Symposium (DS & AD)

AD: In contact with Local Organising Committee and IUGS. Proposed date in August 2021 is completely inappropriate (hot and humid and air is polluted in Delhi). However, these are the only dates that the Convention Centre in Delhi is available. I personally proposed that the 36IGC should be cancelled because the organisation was not up to the standard of other congresses. The question is what we are going to do with the Fourth Arthur Darnley Symposium and the Workshop if IUGS decides to go ahead.
DS: We can't pull out of an IUGS activity if it is decided to go ahead.
AL: Overlap with other conferences (*e.g.*, Irish Symposium in Galway).
AD: We have about 48 registered participants for the two-day Workshop (other tutors: Philippe Négrel from France & David Cohen from Australia).

KK: We should agree to have a presence and discuss details later when the Covid-19 situation is clearer.
DS: Keep The Arthur Darnley Symposium and Workshop on the table for now.

XI. Update on IUGS Council meeting (AD)

AD: IUGS Council Meeting may be held in Paris next November. We should know within the next couple of weeks the time and place. Because of the coronavirus it may be organised as a Zoom meeting.

XII. Plans after the publication of the two sampling manuals, *e.g.*, revision of 'Blue Book' and writing a popular document for the United Nations General Assembly (AD)

AD: Revision of 'Blue Book' is important in order to remove contradictory parts. This issue will be discussed with Chris Johnson and Fiona Fordyce. It is necessary to go through it line by line. It is an important job for after the publication of the Manuals.
KK: I am interested to participate in this.
AD: We need ideas for the future, especially how to reach the UN National Assembly in order to have an agreement by all countries for carrying out the global geochemical baseline project as described in the 'Blue Book' and in the underwriting IUGS Manual of Standard Methods. Also, we should discuss it with UNESCO. The idea is to write a popular book, well-illustrated, simple, and aimed at politicians. This is maybe a task for the new leadership. Of course, the global geochemical baselines project needs funding, but first we need UN to agree on this venture, which is important not only for the present but also the future generations.

XIII. Update on activities of the UNESCO International Centre on Global-scale Geochemistry (XW)

XW: ICGG research on Mapping Chemical Earth programme, initiated 2016 at ICGG inauguration. Existing sampling programme but want to monitor changes, so second round of sampling. Silk Road national scale geochemical mapping, many nations already completed sampling. Training: Each year since 2016 there's been training workshops.
SEE AT THE END NOTES SENT by XW and COMMENTS by AD.

XIV. Other issues

KK: Treasury standing, useful to clarify situation.
AD: Largely dependent on IUGS funding. Situation with external sponsors and how to acknowledge their financial input is not cleared. In fact, this question has been posed to the IUGS EC and we are still waiting for a reply. Roland Oberhänsli's (IUGS Past President) opinion is that sponsors can finance certain activities, but not directly give money to the Commission. So, this is something that should be explored.
DS: Annual Report each year is followed by request for funds for next year.
AD: Last year we had the ARC review. There was a discussion about funding. We asked the members of ARC what level of funding they think is logical, subject to all the annual activities of the Commission. Roland Oberhänsli (IUGS Past President) is of the opinion that an amount of 15,000 US$ per year was fair. So, we submitted such a proposal last January and we received in total 6000 US$, namely 3200 US$ for the 36IGC and 2800 US$ for all the other annual activities. Annual Reports of IUGS Treasury shows they have funds, but they are not willing to provide larger annual allocations to Task Groups and Commissions.
KK: Merit in well-defined projects with clear benefits, and build up over time.

AD: At the EC meeting in Busan last January, we submitted a proposal for the Commission to develop analytical reference materials (RMs). This is an important activity that IUGS should be involved as Commissions are in fact commissioned to set standards. Hence, the reasons for developing the IUGS Manuals of Standard Methods. As a follow-up is the development of analytical reference materials. This issue was discussed with Manfred Birke (BGR) and his opinion is to develop 1-tonne of Reference Materials for each recommended sample type. So, I contacted our Slovakian colleagues, who developed the two GEMAS references materials. The cost of developing the soil and overbank sediment RMs is quite cheap, in the order of 5000 Euros. The problem is the cost of the vials which cost some tens of thousands US$. Manfred, for example, paid 30,000 Euros in RM vials for packing the 150 to 200 kg of the two GEMAS RMs.
KK: In my experience with the development of RMs, while working at BGS, are important and of long-lasting relevance; different elements of interest for different sectors (exploration vs environment). Maybe this is an avenue for collaboration with FAO.
AL: Swedish survey has set on RMs for last 20 years.
KK: Should make this an item for future discussion within the Commission.

XV. Adjournment (DS)

DS: Getting close to allocated time. Time for new leadership to take over, and old guard is there to advise as required (for some time); declare ownership and run with it!
Look forward to seeing this succeed into the future.
GS: Has the new Steering Committee been ratified by the IUGS Council?
AD: No, not yet, but should be done soon.
GPR: Geological Surveys of south/central America, Spain and Portugal are doing their own Manual in Spanish. A video conference is planned for next November to discuss this activity.
AD: Maria João Batista from Portugal is our link to this group, and Maria is the leading co-author in two Chapters of the IUGS Manual, soil and rock. So, the Manual in Spanish will be along the same lines as the IUGS Manual. In fact, we will provide the template in English, and our Spanish speaking colleagues can translate the text, and replace the photographs.

=====ooooo=====00000=====ooooo=====

E-mail message from Xueqiu Wang, 2nd Co-chair (2008-2020), 25 June 2020

Dear All,

I am not sure that my internet connection is good or not during the meeting time. Thus, I write this email to all of you.

Firstly, I would like to say it is a great honour to be with Dave, Alecos and Patrice and work for the leadership of the IUGS Commission on Global Geochemical Baselines (CGGB) in the past 12 years since 2008.

Secondly, I would like to thank all of you for your wholly support for the International Centre on Global-Scale Geochemistry (ICGG) since the initiative for the creation of the ICGG in 2009.
Thirdly, I wish to congratulate persons on your being elected as members of new leadership of the CGGB.

I will continue to give support for the CGGB, though I am no longer Co-leader and step down from the leadership position from today.

Regarding the meeting issues, I provide the following comment on II and materials for XIII of the Agenda.

Best wishes,
Xueqiu Wang

II. Publication of Black Soil manual, and update on the project (AD)

XW: The China Geochemical Baselines project with a sample per 80x80 km grid cell and the China Soil Quality Geochemical Survey Project with a sample per 2x2 km cell has already covered the black soil land in China. I am not specially involved in black soil research. I have consulted Dr. Cheng Hangxin (chenghangxin@igge.cn) from the IGGE, who is the leader of the China Soil Quality Geochemical Survey Project and Ms. Dai Huimin (phone: 86-13889825351) from the Shenyang Centre of the CGS, who is the sub-project leader for the Black Soil-quality Geochemical Survey under the China Soil Quality Geochemical Survey Project. Dr. Cheng said "*the manual cannot be accepted by China scientists, because the China Geological Survey has well designed the sampling manual and widely used in China*". Ms. Dai said "*My colleagues and I have not seen the final draft for the manual and the manual could not be accepted before it is well commented and revised by the specialists of China and the countries with black soils*"[1].

AD: My first comment is that you have raised an issue that has no basis, as you will see below, and if you have also priorly consulted the Commission's Annual reports, or asked me directly for an explanation.

The IUGS Commission on Global Geochemical Baselines (IUGS-CGGB) and the EuroGeoSurveys Geochemistry Expert Group (EGS-GEG) were invited by Dr. Daming Wang, the Assistant Director of Shenyang Geological Survey (now Shenyang Centre of China Geological Survey), for participation in the first Black Soil workshop, which was organised at the beginning of December 2017. At this meeting, Dr. Manfred Birke and I were representing EGS-GEG and IUGS-CGGB, respectively. As is the usual case, all members of the IUGS-CGGB Steering Committee were informed about the IUGS-CGGB involvement. During the Workshop we had extensive discussions with Mrs. Dai Huimin, who is in charge of the geochemical mapping of black soil in north-east China, and Mr. Liu Kai, an applied geochemist who is carrying out the sampling. I stress that the discussion we had does not concern the detailed geochemical survey you are carrying out in China for the China Soil Quality Geochemical Survey Project. The discussion concerned the sampling of black soil in other countries, *i.e.*, the Global Black Soil project, which is now under the auspices of IGCP 665 '*Sustainable Use of Global Black Soil Critical Zone*', and the '*International Black Soil Society*'.

During the writing of the Manual for the Global Black Soil geochemistry, I have collaborated very closely with Mrs. Dai Huimin and Mr. Liu Kai, as well as a very experienced Russian soil scientist, Dr. Igor Savin. For the analytical part, I collaborated with Dr. Manfred Birke and Mrs. Gwendy Hall, and for the quality control with Dr. Christopher Johnson and Professor Ariadne Argyraki. The completed first version of the Black Soil Manual was discussed at a person to person meeting with Mrs. Dai Huimin and Mr. Liu Kai during the second Black Soil Workshop in October 2018, and the final version was again discussed with both of them during the third Black Soil Workshop in November 2019. All these activities are reported in the 2017, 2018 and 2019 IUGS-CGGB Annual Reports.

[1] Comment by Alecos Demetriades, Commission's Sampling Committee Chair:- The co-authors of the Manual agreed that it should remain confidential until its approval by the IUGS Executive Committee and its publication. Hence, it was the only way that Ms. Dai Huimin could avoid any further demands from CGS and IGGE.

Following, the finalisation of the Manual in November 2011, it was reviewed by Dr. David Smith, Dr. Patrice de Caritat and Professor Reijo Salminen. Suggested corrections were made, and it was reviewed for a second time by Dave, Patrice and Reijo. Directly afterwards, the Manual was submitted, together with the letters from the three reviewers, to the IUGS Executive Committee for approval. This is a required condition in order to be published as an IUGS publication. The IUGS Executive Committee approved its publication on the 17th of January 2020.

Due to the COVID-19 pandemic, and lock lockdown we had in Hellas the publication of the '*IUGS Manual of Standard Geochemical Methods for the Global Black Soil Project*' was delayed until now that I was able to acquire an ISBN number from the National Library of Greece.

The above rather detailed report explains that the '*IUGS Manual of Standard Geochemical Methods for the Global Black Soil Project*' concerns the global project, and not the Chinese national project and, therefore, is not required to be approved by Chinese geoscientists. I sincerely hope that you understand the difference.

III. Update on progress of sampling manual; publication plans (AD)

XW: *Which sampling manual?*

AD: I am really surprised of you asking this question after all the discussions we had, and the annual reporting about the progress made. Of course, I mean the '*IUGS Manual of Standard Methods for Establishing the Global Geochemical Reference Network*'. You have contributed a little in the Overbank and Floodplain Sediment Chapters, and the Chapter on Sampling in Desert Terrains to which you are the leading author. The latter will be sent to other people for their input, because as you know there are deserts in other parts of the World, and there appears to be interest in contributing their experiences. The version that will be sent for review by two external applied geochemists will be sent to you for your final comments.

I sincerely hope that the above comments are sufficient for I honestly do not have the time to enter any discussion on common sense matters with you.

XIII. Update on activities of the UNESCO International Centre on Global-scale Geochemistry (XW)

1. Research Activities: Mapping Chemical Earth Programme

The ICGG research activities are focused on Mapping Chemical Earth Programme, which was initiated at the opening ceremony of the ICGG in 2016. It was mainly focused on: (i) Global Geochemical Baselines Network; (ii) China Geochemical Observation Network; (iii) Silk Road national-scale geochemical mapping and compilation of the Silk Road Geochemical Atlas, and (iv) creating a digital Chemical Earth platform allowing anyone to access vast amounts of geochemical data and maps through the Internet.

(i) **Global Geochemical Baselines Network**: Large basin (2000-10000 km^2, generally 3000-5000 km^2) sediment sampling at a density of 1 sample per 80x80 km or 40x40 km, based on the CGGB Global Reference Network grid cells. *The Guideline of Large Catchment Sediment Sampling for Global Geochemical Baselines as a provisional protocol was approved by the ICGG Scientific Committee in 2018 (see Annex 1.1)*. The ICGG has cooperated with Mongolia, Laos, Cambodia, Russia, Colombia and Iran in

the collection of samples. Sampling in Mongolia, Laos, and Cambodia has been completed, and sampling in Russia, Colombia and Iran is ongoing.
AD comment: I indeed hope that you are carrying out this work according to the "*provisional protocol*" that it was agreed at the 2018 meeting for sampling floodplain sediment (see Annex 1.1), because this is the protocol that will be used in the '*IUGS Manual of Standard Methods for Establishing the Global Geochemical Reference Network*'.

(ii) **China Geochemical Observation Network**: The China Geochemical Baselines (CGB) Network was completed between 2008-2014 for temporal sampling to recognise and quantify potential environmental changes of chemical elements, particularly for toxic metals, radioactive elements, carbon, and halogen elements, and the second-round observation was carried out from 2015-2018.

(iii) **Silk Road national-scale geochemical mapping**: Small basin (generally 50-100 km^2) sediment sampling at a density of 1 sample per 10x10 km. The ICGG has cooperated with Mongolia, Kazakhstan, Uzbekistan, Pakistan, Laos and Cambodia for the collection of samples. Sampling in Laos, Uzbekistan, Pakistan, Laos and Cambodia was completed. Sampling in Mongolia and Kazakhstan is ongoing.

(iv) **Digital Chemical Earth platform**: Data and maps of 40 elements in China have been uploaded onto the website (www.globalgeochemistry.com), the other elements are waiting for the CGS evaluation. Maps of 27 elements prepared from the continental-scale data have been uploaded to the website.

2. Training Courses

- 2016 ICGG Training Course on Geochemical Mapping, Langfang, China.
- 2016 Training course for Cambodia Geochemical Mapping-Field sampling, Phnom Penh, Cambodia.
- 2017 ICGG Training Course on Geochemical Mapping, Langfang, China.
- 2017 ICGG Training Course on Geochemical Mapping for Laos-Field Sampling, Vientiane, Laos.
- 2018 ICGG Training Course on Geochemical Mapping and Environmental Assessment, Langfang, China.
- 2018 ICGG Training Course on Geochemical Mapping, Langfang, China.
- 2018 The 1st Latin American Workshop on Geochemical Mapping, Bogota, Colombia.
- 2019 ICGG Training Course on Geochemical Mapping, Langfang, China.
- 2019 ICGG Training Course on Geochemical Mapping-Software Use, Langfang, China
- 2019 The 2nd Latin American Workshop on Geochemical Mapping, Buenos Aires, Argentina.

Minutes by Patrice de Caritat, Scientific Secretary

ANNEX 1.1: PROVISIONAL PROTOCOL APPROVED BY THE UNESCO-ICGG SCIENTIFIC COMMITTEE IN 2018

The catchment sediment sampling for the Global Geochemical Baselines was agreed as the '*Provisional Protocol*' of the ICGG with signatures of support by Wang Xueqiu, Patrice de Caritat, Gloria Prieto, Zhang Chaosheng, João Henrique Larizzatti, Zhang Bimin, Zhou Jian, Chi Qinghua, Yao Wensheng, Liu Qingqing, Wang Lijun, Wu Qiong and with '*Reservations*' by Alecos Demetriades.

It is noted that only four members of the UNESCO-ICGG Scientific Committee were present at the meeting of the 17th of October 2018, and these are: Gloria Prieto, Wang Xueqiu, Patrice de Caritat and Alecos Demetriades. Gloria Prieto chaired the meeting on the 17th of October 2018 in the absence of the Acting Chair, Roland Oberhänsli (IUGS President 2012-16), who was elected on the 16th of October 2018, following the withdrawal of Alecos Demetriades' candidacy.

Nine members were absent: David Smith, Liu Congqiang, Dong Shuwen, Ni Shijun, Cheng Qiuming (IUGS President 2016-20), Jiang Shaoyong, Wu Fengchang, Davies Theophilus Clavell, and Igor Spiridonov.

The other signatories were observers without voting rights, according to the UNESCO-ICGG Statutes. However, Wang Xueqiu (Executive Director) insisted that they should sign the protocol.

Annex 1.1.1. Agreement on Catchment Basin Sediment Sampling

1. Unified sample media: catchment basin sediment.
2. Catchment basin samples should only be collected, and no other sampling media for the current ICGG global-scale geochemical baselines.
3. Sample site selection: A natural and undisturbed site should be sampled. In case, such a site cannot be found, then the samples should be taken from the least disturbed site.
4. The surface vegetation and litter should be removed before taking the surface sample. When taking the samples, the roots shall be removed.
5. Depth: Two samples are collected at each site: a top sample and a deep sample. Top samples, which may represent anthropogenic emission of mining, industries, residents, pesticides and fertilizers, are collected from:-
    a) a depth of 0-25 cm if the first horizon cannot be clearly recognized;
    b) a depth of 0-25 cm if thickness of the first horizon is more than 25 cm;
    c) a depth from the surface to the first horizon if the thickness of first horizon is less than 25 cm (the depth range is recorded);

    Deep samples, which may represent the natural background, are collected from:-
    a) a depth of more than 100 cm (generally from 100-125 cm section) if the horizon is deeper than 100 cm, or
    b) the deepest accessible depth of horizon (a 25 cm section) if the soil horizon does not have a depth of 100 cm.
6. Field sampling checks: Daily check of all samples and field observation records should be made. In China, project leader or external supervisor checks 3% of the total number of sample locations. In other countries, it is recommended that similar checks are made.
7. Before final approval, the draft is recommended to be accepted for provisional protocol used in the ICGG.

APPENDIX 2: MINUTES OF VIRTUAL MEETING, 2 OCTOBER 2020

Time: 15:00 London

Present:
Anna Ladenberger (AL)
Katherine Knights (KK)
Gloria Prieto Rincón (GPR)
Gloria Namwi Simubali (GNS)
Christina Stouraiti (CS)
Paula Adánez Sanjuan (PAS)
Ariadne Argyraki (AA)
David Smith (DS)
Alecos Demetriades (AD)
(9 participants)

Patrice de Caritat sent his best wishes for a successful meeting and his apologies because of other pressing commitments and the time difference it was not possible to participate.

AGENDA

1. Committee members personal presentation
2. Practical plans for the year 2020-21 (Manual, *etc.*)
3. Old committee networks and contacts – how do we continue?
4. Extraordinary Session of the IUGS Council
5. Future communications, including website updates
6. Establishing contacts, grow them, and communicate effectively
7. Global databases
8. International survey about national and company geochemical surveys performed, and data availability (Compilation of questionnaire)
9. Reference materials
10. Discussion and comments on new IUGS Initiatives and Task groups: Forensic Geology initiative and Isotope Geology and Geochronology Task Group
11. Proposal to organise an Ideas session of what the Commission should be doing
12. Any other items for discussion

VIRTUAL MEETING

1. Committee members personal presentation.

AL: Welcomed all Steering Committee members, and started the round of personal presentation – research interest and current work. She suggested that it will be good to have more personal presentation of ourselves, about our way to the surveys, research interests, current work and duties.

2. Practical plans for the year 2020-21 (Manual, *etc.*)

AD: The plan is to complete the Manual, if possible, by the end of the year, or the first months of 2021, and to be published in 2021 after its approval by the IUGS Executive Committee. The former IUGS President, Roland Oberhänsli, recommended to get in touch with UNESCO for it

will be advantageous if UNESCO undertakes to publish it in hard copies, and sends it to all geoscientific institutions as it did with the 'Blue Book'. I have contacted Ozlem Adiyaman Lopes (Programme Specialist on the International Geosciences Programme) last December, and there may be a possibility. We agreed to contact her again when we are near the end.

Revision of 'Blue book' by removal of contradictory parts (2021).

Compilation of a popular well-illustrated book for politicians and laypersons. This came up in the discussions with Roland Oberhänsli (Past IUGS President) that such a book is important, and to reach the highest international body, which is the United Nations General Assembly. If a decision is taken for the Global Geochemical Baselines mapping at this level, then financial resources may be much easier, *e.g.*, World Bank, *etc.* Roland promised to help in this venture. So, I consider this item particularly important, and in my opinion requires a feminine touch.

3. Old committee networks and contacts – how do we continue?

AD: As I been communicating with the EGS-GEG and IUGS-CGGB members, over the next few days, I will be checking the two lists, and most likely I will combine the two, and will send you all one list for communication. At one time, I held the post that Ariadne holds now (Public Relations and Finance) and, therefore, it was my responsibility to contact the international community and increase the membership. So, my recommendation is for Ariadne to take-up this role. I have not yet informed let us say the Commission's members, about the new Steering Committee for two reasons:

Firstly, the names of the New Steering Committee to be uploaded to the IUGS website, and now they are: https://www.iugs.org/commissions, and secondly the same information to be at the CGGB website: http://www.globalgeochemicalbaselines.eu/content/94/steering-committee-/. Ariadne, as Public Relations officer, should take-up the communication in order for me to inform all CGGB members the names and contact details of the new Steering Committee, and to thank them for their collaboration all these years, and also to remind them of the existing Regional Officers and Committees to whom they should send their reports.

Regarding the Annual Report, Dave used to get in touch with all the Regional Officers, so he has to transfer this work to Anna and Paula, and Dave has to follow the same procedure of informing them about the change.

4. Extraordinary Session of the IUGS Council

AD: I am in touch with the IUGS Secretary-General about the usual ten-minute presentation on the work done by CGGB from 2016-2020, and a slide about plans for future work. There is no decision yet. My information is that details will be provided the latest by mid-October.

AL: Have you received documents about the Extraordinary session, *e.g.*,
three resolutions, and Slate of Candidates for the IUGS Nominating Committee?

AD: As I am Deputy National Hellenic Delegate, this information is sent to me, and can be sent to all of you.

5. Future communications, including website updates

AD: Ariadne, as Public Relations and Finance officer, should be taking up the website updates. Apart from being her responsibility, some terms are still in the Hellenic Language, and the

Manual is in Greek. My recommendation is for Christina to be trained too. I also propose when there is a major update to inform CGGB members.

6. Establishing contacts, grow them, and communicate effectively

AD: This is indeed a difficult task. Arthur Darnley during the eight years of the two IGCPs, 259 and 360, was compiling a quarterly newsletter, which was sent to all IUGS member surveys. This is something that we have never taken up because all of us had our Survey work. Arthur during the eight years of the two IGCPs was working full-time on these projects. So, he had the time to do it. Therefore, it will be good if somebody volunteers to compile an e-Newsletter, if not quarterly, semi-yearly. Of course, to compile such a Newsletter requires input by the member countries.

Another option that is now available is the monthly IUGS e-Bulletin. Articles can be compiled and published at regular intervals, and then inform the CGGB members.

7. Global databases

AD: This is the responsibility of the Data Management Committee, which is chaired by Timo Tarvainen. The Committee met in Athens in May 2009, and decided on the structure of the metadata base, and Igor Bogatyrev designed it using the structure of the Northern Europe Geochemistry (NEG) project https://gsi.ir/en/articles/9394/northern-europe-geochemistry-neg-a-metadata-base-for-21-international-and-national-regional-geochemical-databases. This database was stored on the server of the Hellenic Institute of Geology and Mineral Exploration. Unfortunately, there was a problem with the server, and I was informed that the database could not be retrieved. I am certain that Igor Bogatyrev has a back-up copy, so I will ask him to send it to me in order to upload it to the server of the CGGB's website hosting company.

Please note that the decision of the Data Management Committee is that metadata stored in this metadata base concern only projects that meet the requirements of the 'Blue Book'.

8. International survey about national and company geochemical surveys performed, and data availability (Compilation of questionnaire)

AD: This is a good idea. Arthur Darnley sent a questionnaire to all Geological Surveys, and a summary table is in the 'Blue Book'. Also, the WEGS Regional Geochemistry Working Group has carried out a European survey in 1990, and five years later a similar survey was carried out by the FOREGS Geochemistry Task Group. These data are in reports:

Bølviken, B., Demetriades, A., Hindel, A., Locutura, J., O'Connor, P., Ottesen, R.T., Plant, J., Ridgway, J., Salminen, R., Salpeteur, I., Schermann, O. & Volden, T. (Editors), 1990. Geochemical Mapping of Western Europe towards the Year 2000. Project Proposal. Western European Geological Surveys (WEGS). Geological Survey of Norway, Trondheim, NGU Report 90-106, 12 pages and 9 appendices; http://www.ngu.no/upload/Publikasjoner/Rapporter/1990/90_106.pdf.

Plant, J.A., Klaver, G., Locutura, J., Salminen, R., Vrana, K. & Fordyce, F., 1996. Forum of European Geological Surveys (FOREGS), Geochemistry Task Group 1994-1996 Report. A contribution to IUGS Continental Geochemical Baselines. British Geological Survey, Keyworth, Nottingham, U.K., BGS Technical Report WP/95/14, 52 pp.; http://nora.nerc.ac.uk/id/eprint/19012/1/WP95014.pdf.

9. Reference materials

AD: This is an excellent idea, and it has already been proposed in January to the IUGS EC that IUGS must undertake the development of international reference materials. These are definitely needed for I am almost certain that it will be necessary to level the data when the global project is completed. BGS has this experience with the regional stream sediment survey, which has been going on for the past fifty years. There is a Chapter in the Manual on Data Conditioning written by Christopher Johnson and Bob Lister (BGS) – Bob Garrett and Kate have reviewed this Chapter. IUGS has the money to develop such reference materials, the problem is to convince the new EC to finance it.

10. Discussion and comments on new IUGS Initiatives and Task groups: Forensic Geology initiative and Isotope Geology and Geochronology Task Group

AL: It is important to link to these two Groups because both of them are concerned with geochemistry.

11. Proposal to organise an ideas session of what the Commission should be doing

AL: It is important to organise a Zoom ideas session early in the new year.

12. Any other items for discussion

AD: Goldschmidt 2021: At the Budapest meeting, we have discussed to organise a session in 2021, since it was going to be in Lyons. This will be a joint organisation with the EuroGeoSurveys Geochemistry Expert Group.

The CGGB bank account cannot be transferred yet to Christina and Ariadne, because I am still waiting for the reimbursement of the hotel booking from the 36th IGC. So, it will be done directly after the reimbursement.

This month CGGB pays the annual web hosting fee, which is 240.50 Euros.

I accidentally found that Google Analytics no longer works. The reason is that the Google Analytics script has to be copied on all web pages. So, I asked the Web hosting company to inform us of the cost. Also, when working with Ariadne on the web pages, we noticed that the drop-down windows need a yellowish colour in order for the items to be seen more clearly. So, we have asked the company if this can be done and, of course, the cost.

Organisation of the 2021 joint annual physical meeting in Athens next November, subject to being safe for travel.

As virtual meetings are organised nowadays, it may be a good idea to organise a global meeting with national presentations directly after the publication of the IUGS Manual of Standard Methods for GGB.

AL: Thanked all participants for their participation, and especially their presentation of themselves, and closed the meeting.

Minutes by Paula Adánez Sanjuan, Scientific Secretary

APPENDIX 3: PRESENTATION IUGS VIRTUAL COUNCIL MEETING

Report on the 2016 to 2020 activities of the IUGS Commission on Global Geochemical Baselines

Alecos Demetriades, David Smith, Patrice de Caritat and Ariadne Argyraki

http://www.globalgeochemicalbaselines.eu/

Establishment and long-term mission

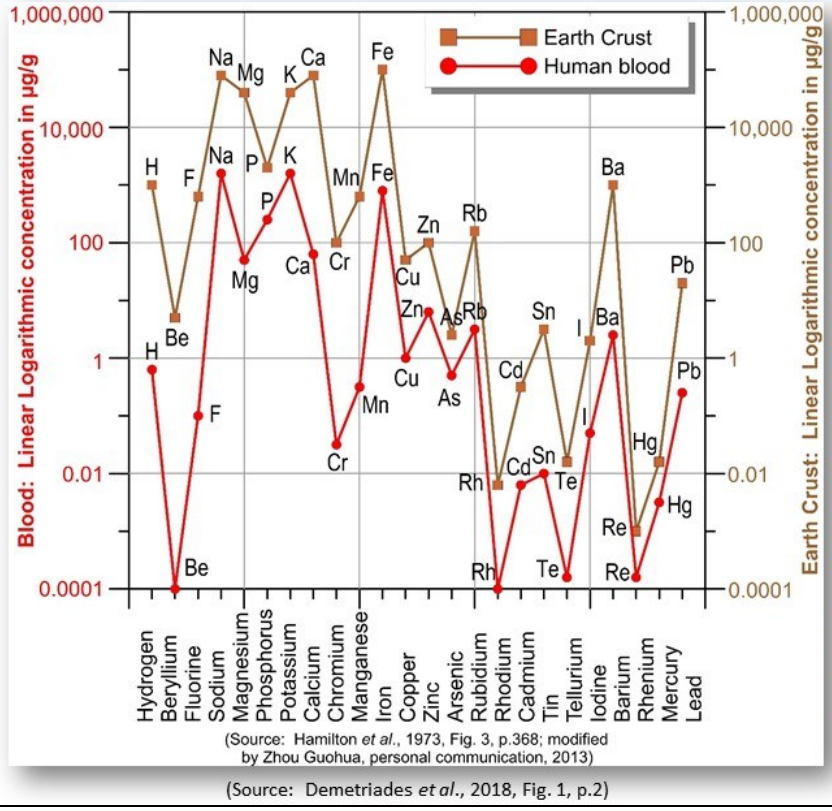
On the 31st of August 2016 at the Fourth Ordinary Session of the IUGS Council Meeting in Cape Town the establishment of a Commission on Global Geochemical Baselines was approved (*It will be referred to as Commission from now on*).

The long-term mission of the Commission is:

- To standardise global-scale geochemical baselines methods;
- To prepare a global geochemical baselines database, and its representation in map form, and
- To document the concentration and distribution of chemical elements and their compounds in the Earth's near-surface environment.

All Commission activities are reported in its annual reports, and the 2016-2020 summary report, which are available at: https://www.globalgeochemicalbaselines.eu/content/90/annual-reports-/

The relationship of the Commission's work with our quality of life is shown in this diagram:



(Source: Hamilton *et al.*, 1973, Fig. 3, p.368; modified by Zhou Guohua, personal communication, 2013)

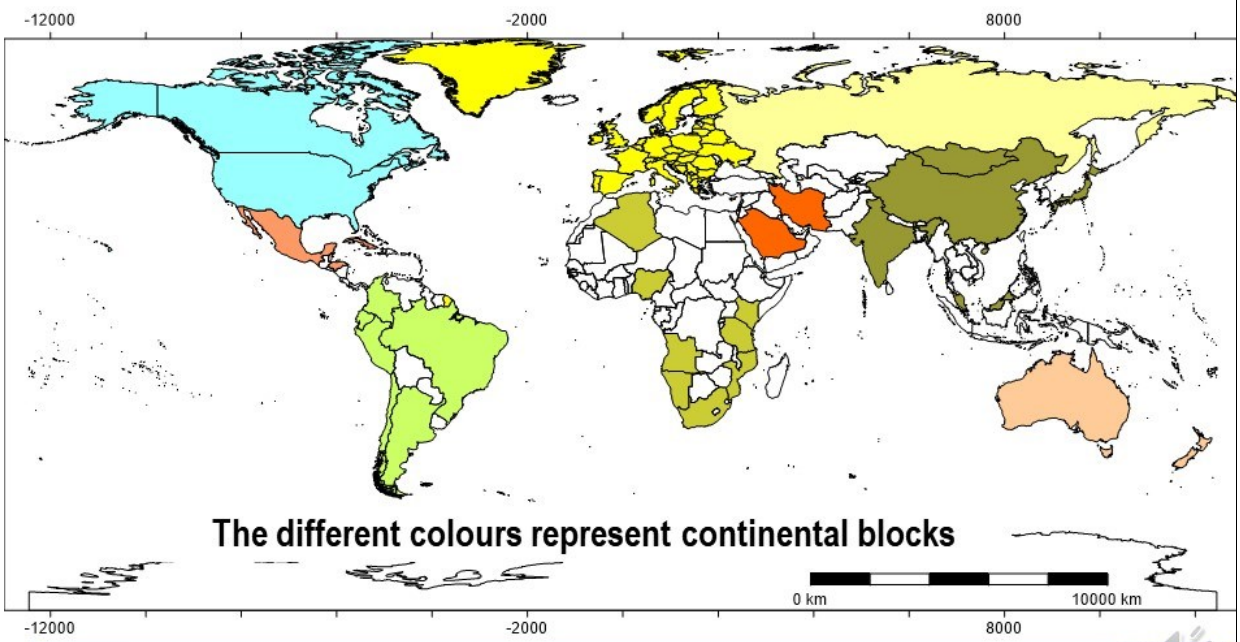
(Source: Demetriades *et al.*, 2018, Fig. 1, p.2)

where the correlation of the concentrations of selected chemical elements in ***Human blood*** **(red line)** and the ***Earth's crust*** **(brown line)** can be observed.

It can be then concluded that ***our quality of life and health are, in fact, closely related to the chemistry of Earth materials.***

Commission's Global Membership

148 members in 69 countries

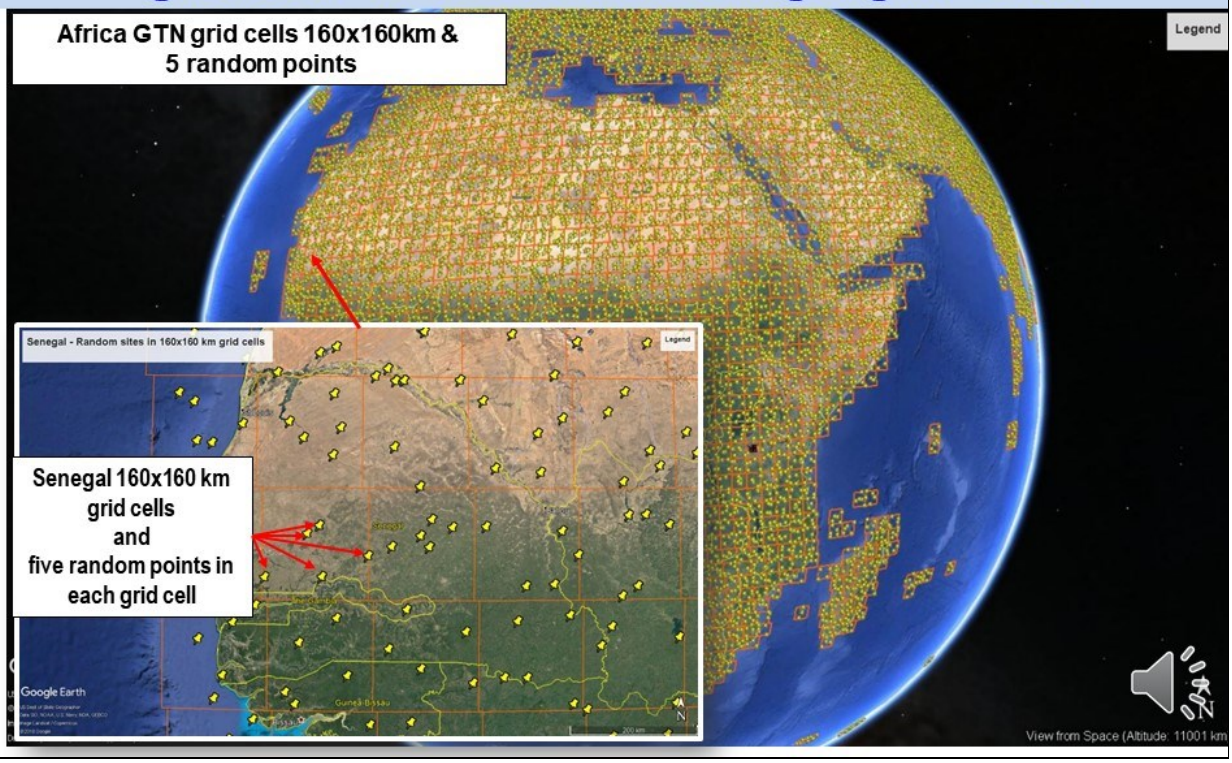


Manual of standard methods for establishing the Global Geochemical Reference Network

As the work of IUGS Commissions is to set standards in the earth sciences, the Commission's main work since February 2018 is the compilation of the '***International Union of Geological Sciences Manual of Standard Methods for Establishing the Global Geochemical Reference Network***'.

Due to the difficulties involved, as many colleagues are contributing to this important reference work from all over the World, it is expected to be completed and published in 2021.

Africa with the Global Terrestrial Network grid cells of 160x160 km, and the five random points in each grid cell. Inset shows Senegal grid cells.



Relationship with the UNESCO International Centre on Global-Scale Geochemistry (Centre)

At the second meeting of the Centre's Governing Board on the 16th of October 2018 the relationship between the Commission and the Centre was clearly stated in its approved and ratified Statutes:

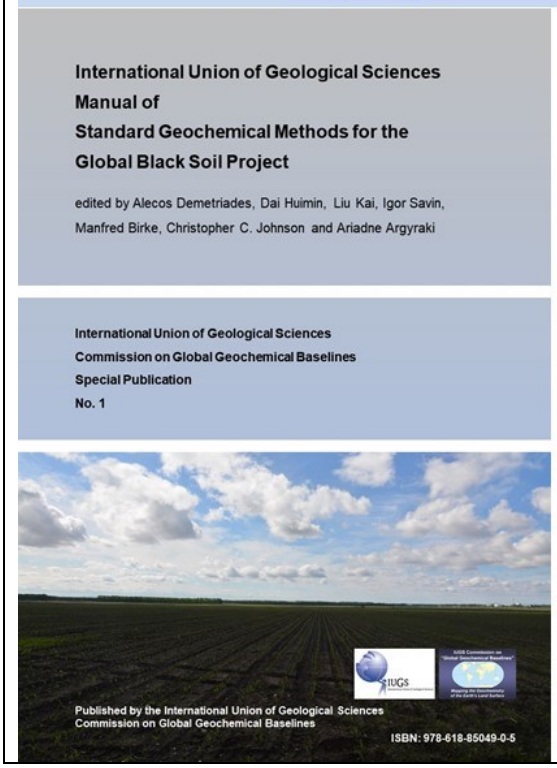
According to Article 7.1, the functions of the Centre shall be to:

- *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.*

Hence, the Commission is setting up the work standards with the compilation of the IUGS Standard Methods Manual.

Global Black Soil Critical Zone Geo-ecological Survey (BASGES)

http://globeblacksoils.org/news_en/



In the autumn of 2017, the Commission was invited to participate in the BASGES project, and to compile a Manual of Standard Geochemical Methods for the Global Black Soil Project. The work was completed at the end of 2019, and the IUGS Executive Committee approved its publication at its 74th meeting in Busan last January.

It is now freely available and can be downloaded from the Commission's website.

In December 2018, two papers on the Commission's work were published and are freely available on-line:

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.

Since January 2019, the Commission's New Website is in operation

ASSISTANCE WAS PROVIDED TO COMMISSION MEMBERS AND WORKSHOP PARTICIPANTS FROM

- Brazil,
- Brunei,
- Chile,
- China,
- Morocco, and
- Namibia.

The assistance concerned mainly the supply of the Global Terrestrial Network grid cells of 160x160 km, and random sites. Also, planning of sampling campaigns at different mapping scales.

Letters of support were provided for Ph.D. applications to attendees from Congo and Iran of YES Workshops, which were organised in Tanzania, Iran and Germany.

IUGS Commission on "Global Geochemical Baselines"
Mapping the Geochemistry of the Earth's Land Surface

Thank you for your attention

@CGGBIUGS

@CGGB_IUGS

http://www.globalgeochemicalbaselines.eu/

Blank back page

APPENDIX 4: TIERRA DEL FUEGO RECONNAISSANCE SURVEY

RECONNAISSANCE SURVEY OF THE CHILEAN PART OF TIERRA DEL FUEGO, A SUB-ANTARTIC TERRAIN, AS A CONTRIBUTION TO THE IUGS MANUAL OF STANDARD METHODS FOR GLOBAL GEOCHEMICAL BASELINES AND REGIONAL GEOCHEMICAL SURVEYS

Juan Pablo Lacassie*, Felipe Astudillo, Carlos Johnson & Pablo Sebastian Oliva Vicentelo

Servicio Nacional de Geología y Minería (Geological and Mining Survey of Chile)

(*) Chilean delegate, IUGS Commission on Global Geochemical Baselines

---

TECHNICAL REPORT

Valdivia, Chile, October 2020

Front cover photograph: Juan Lacassie Reyes on the left, and Felipe Astudillo on the right. Photograph by Carlos Johnson, Servicio Nacional de Geología y Minería (SNGM).

CONTENTS

Blank back page

EXECUTIVE SUMMARY

Between the 24th of February and 2nd of March 2020, a geological and logistical reconnaissance survey was carried out on the Chilean sub-antarctic area of Tierra del Fuego. This work is a contribution to the '*International Union of Geological Sciences Manual of Standard Methods for Global Geochemical Baselines and Regional Surveys*', which is currently being developed by the IUGS Commission on Global Geochemical Baselines, according to the specifications of the 'Blue Book' by Darnley *et al*. (1995).

The island of Tierra del Fuego, which is divided between Chile and Argentina, is covered by six Global Terrestrial Network grid cells of 160x160 km, i.e., from north to south and west to east: S36W30, S36W31, S37W28, S37W29, S37W30 and S37W31 (Figure A4.1).

During this field campaign, a tour of the main routes in the Chilean part of Tierra del Fuego was made, starting from Bahía Azul in the north until Caleta María in the Almirantazgo Sound at the southernmost tip of the island was reached. The geological and geomorphological conditions for carrying out geochemical sampling of sub-antarctic stream sediments, stream water, floodplain sediments, overbank sediments, residual soil and rock were assessed and verified.

In particular, the 8 sites that were studied in detail are distributed from the extreme north to the extreme south of the island, where the characteristics of residual soil and sediments representative of the different geomorphological environments of the area were assessed, including fluvio-alluvial terraces, floodplains and glaciofluvial deposits.

In geological and geomorphological terms, the following were verified:

(i) All sample types that are required to be collected in each Global Terrestrial Network grid cell of 160x160 km, according to the specifications of the IUGS Commission on Global Geochemical Baselines, are available, *i.e*., stream sediment, stream water, overbank sediment, residual soil and rock from second order streams, and floodplain sediment from third or higher order streams. Fine-grained overbank and floodplain sediments are exposed on riverbanks, and can also be sampled from the floodplains and terraces. In particular, a large part of the fluvial sediments has a distal origin, so their chemical composition can be used effectively to define a baseline on a regional scale, and/or to delineate prospective zones within the catchment basin.

(ii) There are extensive floodplains with different levels of deposition that are accessible for sampling either by digging pits or clearing exposed stream-/river-bank sections.

(iii) Residual soil development on glaciofluvial deposits (till) is weak or moderate and the soil type is Cambisol, according to the Harmonised World Soil Data Base (FAO/IIASA/ISRIC/ISS-CAS/JRC, 2009). This soil type is characterised by a low degree of chemical weathering due to the prevailing Tierra del Fuego climatic conditions, *i.e*., tundra – cold winter (-2 to 5ºC) and cool summer (5.4 to 14ºC), and average annual rainfall of 578 mm. Hence, the chemical composition of residual soil can be used for prospective purposes too.

(iv) Oxidation conditions have been observed in fluvial sediments and residual soil. It is, thus, recommended to avoid sampling fluvial sediments or residual soil that show reddish-brown colouration associated with oxidation processes, because of possible remobilisation of chemical elements.

(v) Residual soil and overbank-floodplain sediment samples are collected from single horizons and layers, respectively. In case, the soil horizon or sediment layer is less than the specified thickness of 20 cm, then the thinner horizon or layer is sampled, and the thickness recorded on the field observations sheet. Samples must never be collected from different soil horizons and overbank-floodplain sediment layers, because of differences in their chemical composition.

In logistical terms, the following were verified:

(i) It is possible to access the fluvial and stream courses of interest at their intersection with roads and paths. However, in order to carry out geochemical sampling over the whole area access permissions to private properties are required, and they must be obtained prior to the start of the field campaign.

(ii) The climatic conditions are adverse (strong and constant wind, intermittent rain), which would make it difficult to set-up camp. In addition, there are few logistics operation centres (*i.e.*, fitting the budget available for field campaigns), which allow access to lodging, groceries and fuel. It is, thus, crucial to carry out a reconnaissance survey prior to field campaigns in remote sub-polar regions. In particular, due to the scarcity and distance of refuelling stations, it is necessary to carry extra fuel, thus the reason for recommending the use of certified fuel tanks.

A4.1. INTRODUCTION

Between the 24th of February and 2nd of March 2020, a reconnaissance field survey was carried out in Tierra del Fuego of southern Chile. The main objective of this campaign was to gather geological and logistical information that will serve as a contribution to the '*International Union of Geological Sciences Manual of Standard Methods for Global Geochemical Baselines and Regional Surveys*', which is currently being developed by the IUGS Commission on Global Geochemical Baselines.

This report describes the main results of this reconnaissance survey, including the geological and logistical aspects, which are considered relevant for the purposes of planning the geochemical survey of stream, overbank and floodplain sediments, stream water, residual soil and rock in sub-antarctic or sub-polar conditions, using Tierra del Fuego in southern Chile as an example (Figure A4.1). The collected information is broken down according to what was observed at each one of the 8 field sites where geological observations and/or studies of the residual soil and floodplain sediment profiles were made (Figures A4.2 & A4.3).

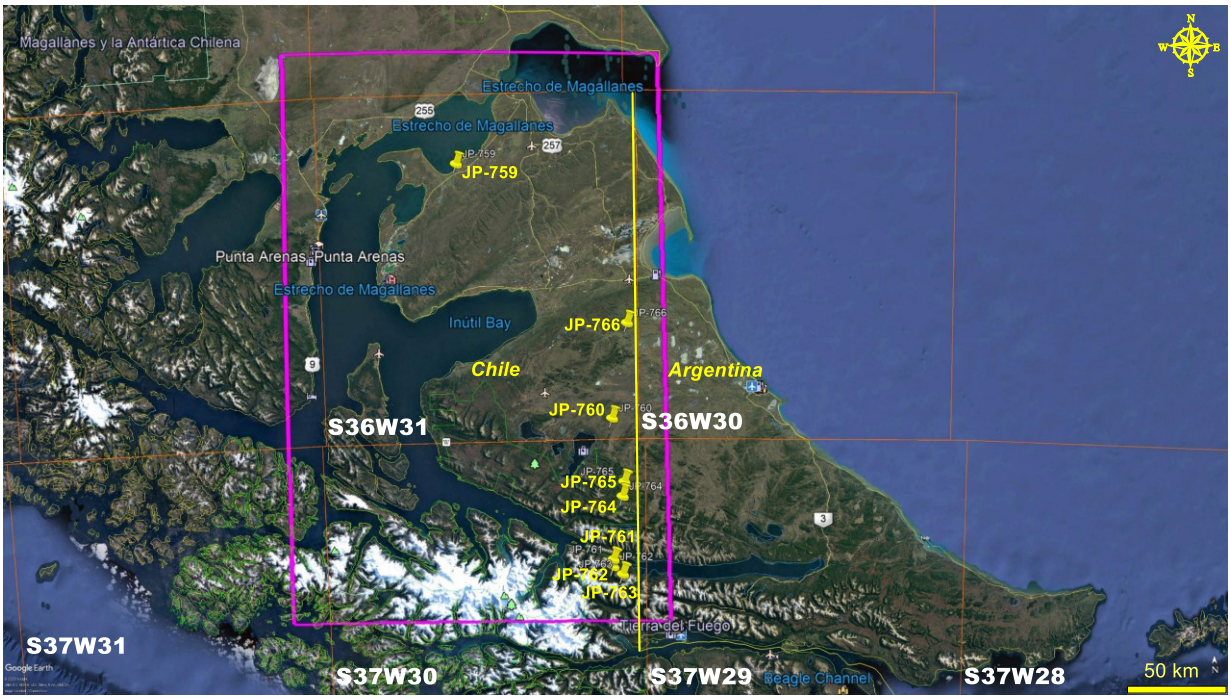


Figure A4.1. Satellite image (Google Earth) of the extreme south of South America, including Tierra del Fuego with GTN grid cells S36W30, S36W31, S37W28, S37W29, S37W30 and S37W31 (squares defined by red colour lines). The positions and identification codes of the 8 field sites, where geological observations and/or residual soil and overbank-floodplain sediment profiles were made are indicated by yellow pins. The magenta rectangular box, of approximately 300x500 km, corresponds to the area covered by Figure A4.2. The yellow vertical line is the international boundary between Chile (western part of the main island plus the islands south of Beagle Channel) and Argentina (eastern part of the main island). Plotted by Pablo Sebastian Oliva Vicentelo (SNGM).

A4.2. GEOLOGICAL FRAMEWORK

On a regional scale, the following geological units are recognised in Tierra del Fuego (Figure A4.2; extracted from Sernageomin, 2002):

- **Q1 (Pleistocene-Holocene):-** Alluvial, colluvial and mass removal deposits; to a lesser extent fluvioglacial, deltaic, littoral or undifferentiated.
- **Q1g1 (Pleistocene-Holocene):-** Moraine, fluvioglacial and glaciolacustrine deposits: block diamicts and silt/clay matrix, gravel, sand and silt. In the Central Depression, it

corresponds to moraine lobes in front of the periglacial lakes, frontal fluvioglacial fans or varves on the shore of lakes or rivers, associated with the main phases of the Pleistocene glaciation where they are undifferentiated or related to the Llanquihue glaciation phases (35-14.2 ka).

- **E1m (Eocene):-** Marine sedimentary sequences: sandstone and shale of the Bahía Inutil Group.
- **EM1m (Eocene-Miocene):-** Sub-coastal marine sedimentary sequences: siltstone and claystone of the Bahía Inutil Group.
- **M1c (Lower-Middle Miocene):-** Sedimentary sequences of alluvial, pediment or fluvial fans: gravel, sand and silt with interspersed ignimbrite from the Las Dunas Formation.
- **M1m (Miocene):-** Transgressive platform marine sedimentary sequences: fine-grained sandstone, claystone and siltstone.
- **Ks1m (Upper Cretaceous):-** Platform, littoral or transitional marine sedimentary sequences, consisting of sandstone, conglomerate, shale, extraclastic and oolitic limestone, and turbiditic successions of the Cerro Toro and Punta Barrosa Formations.
- **Ks1mp (Campanian-Maastrichtian):-** Marine and paralic sedimentary sequences: sandstone and shale of the Tres Pasos, Rocallosa, Fuentes, Cerro Cuchilla and Dorotea formations.
- **JK1m (Upper Jurassic-Lower Cretaceous):-** Littoral or platform marine sedimentary sequences: limestone, shale, calcareous sandstone, sandstone and coquina from the La Paciencia, Erezcano, Zapata, Sutherland, Río Jackson, Vicuña and Yaghán Formations.
- **J3a (Jurassic):-** Volcanic sequences and centres: dacitic to rhyolitic pyroclastic rocks, andesitic lavas and sedimentary intercalations of the Ibáñez Group and the Tobífera Formation.
- **DC4 (Devonian-Carboniferous):-** Metasandstone, phyllite and, to a lesser extent, marble, chert, metabasalt and metaconglomerate; metaturbidite with 'mélange' facies from the Eastern Metamorphic Complex of Aisén y Magallanes.

A4.3. FIELD OBSERVATIONS

The coordinates of the studied field sites, the Strahler stream order magnitude number and the sample type are given in Table A4.1. The observations made at each site are described below.

Table A4.1. Field site UTM WGS 84 coordinates, Strahler stream order magnitude (Strahler, 1969), and sample type. The stream order classification is at a map scale of 1:50,000.

Sample site ID	UTM East	UTM North	Stream Order (Strahler)	Sample type
JP-759	439321	4144146	3	Floodplain sediment
JP-760	512448	4021449	1	Residual soil
JP-761	512122	3954096	2	Overbank sediment
JP-762	511941	3950694	1	Rock outcrop
JP-763	516439	3947072	1	Rock outcrop
JP-764	516919	3984200	1	Residual soil
JP-765	517854	3991129	2	Overbank sediment
JP-766	520277	4066771	2	Overbank sediment

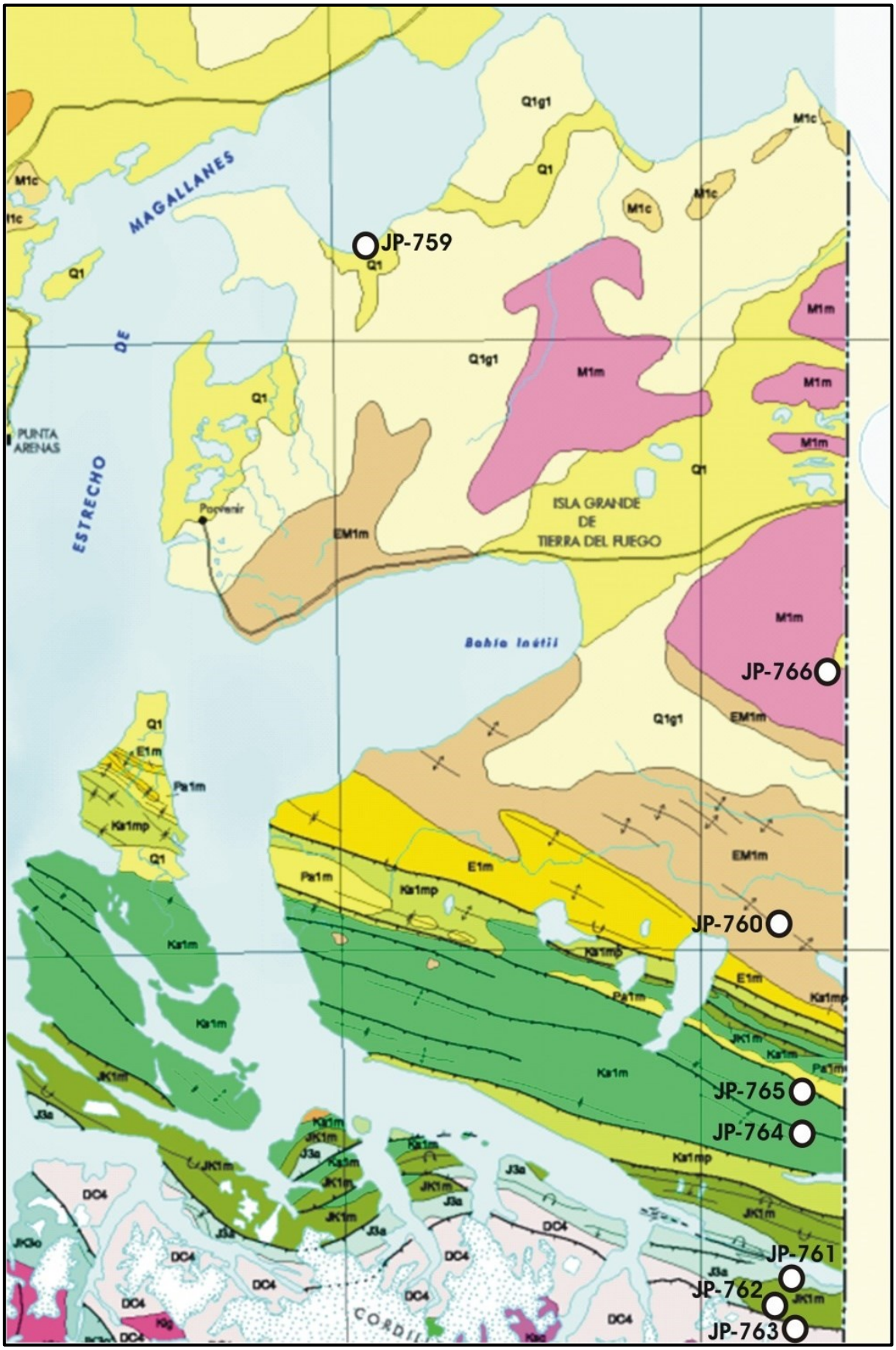


Figure A4.2. Geology of Tierra del Fuego (extracted from Sernageomin, 2002) of the area defined by the rectangular red box in Figure A4.1. The description of the geological units is given in the section of 'Geological framework' in this report. The position and code of the field sites are marked by white circles where geological observations of sediment and soil profiles were made.

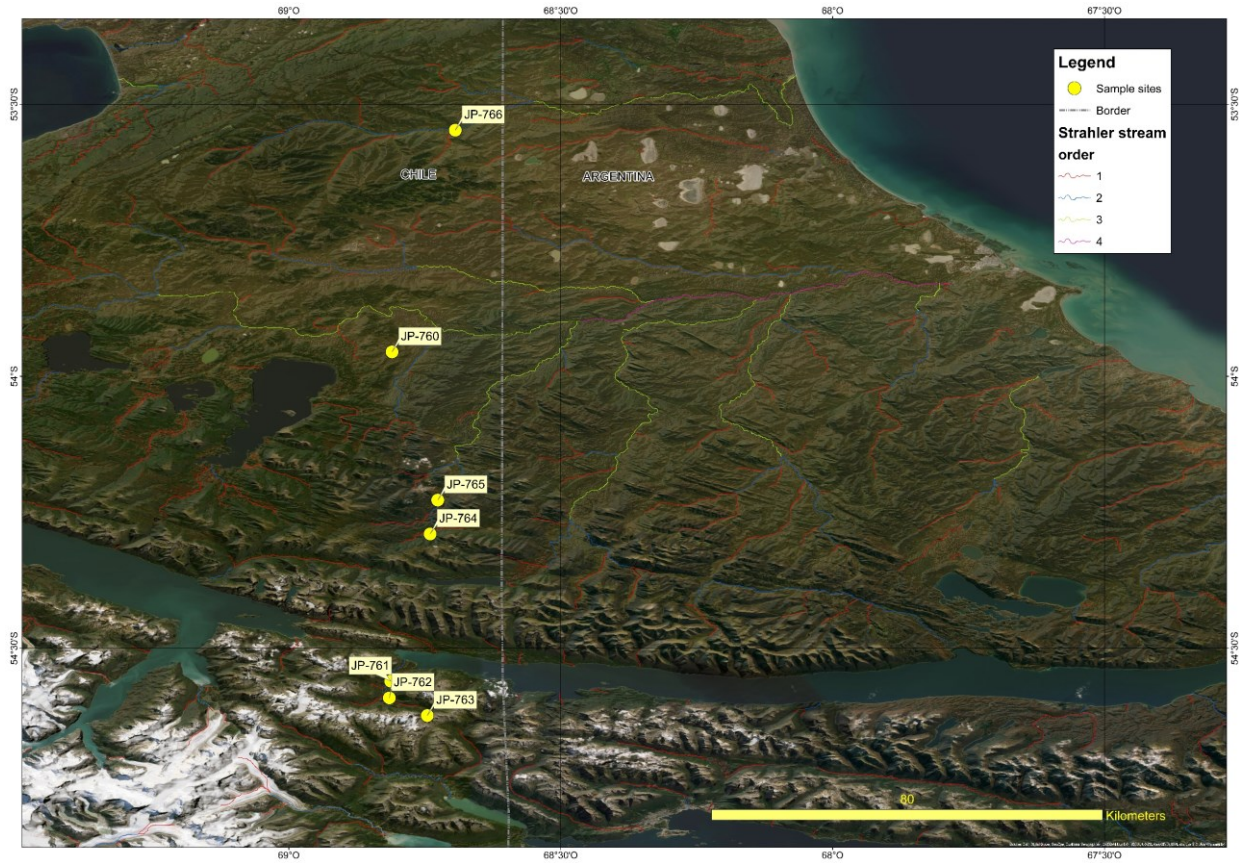


Figure A4.3. Google Earth image of Tierra del Fuego reconnaissance survey area showing the drainage classified according to the Strahler stream order magnitude system (Strahler, 1969), and the field sites where observations were made (see Table A4.1 for sample site coordinates and stream order). The stream order classification is at a map scale of 1:50,000. Site JP759 is about 112 km to the NW of site JP766 (see Figure A4.1), and is situated on Río del Oro, a third order stream that flows into the Strait of Magellan. Plotted by Pablo Sebastian Oliva Vicentelo (SNGM).

A4.3.1. Field site JP-759: Floodplain sediment

This site is situated on the floodplain of the second order Río del Oro (Table 1), which meanders in its exceptionally low gradient floodplain, and on its banks are good exposures of floodplain sediments (Figure A4.4), according to the stream order classification of fluvial sediments by Darnley *et al*. (1995) and Salminen, Tarvainen *et al*. (1998). The observed floodplain sediment deposits coincide with the expected fluvioglacial and deltaic deposits associated with the Q1 unit (Figure A4.2).

The exposed floodplain sediment profile has a thickness of approximately 360 cm (Figure A4.5). There are two thick floodplain sediment sequences, one at the bottom (>85 cm thick), and the second at the top (≈135 cm thick). In the middle section, there is a sequence of alternating medium to coarse-grained stream sediments and fine-grained floodplain sediments indicating that the river channel was shifting, and changes from medium-energy and low-energy flow conditions. The colour variation of the top floodplain sediment layer, the dark grey to blackish colour (down to the dash-line), and the whitish part down to the dotted-line is considered to be due to gleisation, which most likely was caused by the inundation of water over the floodplain. The recession of flood water was most likely extremely slow producing water-logged and swampy conditions causing a reducing environment due to water saturation and, thus, the reduction of Fe. The presence of preserved camelid skeletons in the top floodplain sediment sequence is consistent with low-energy and reducing conditions.

The occurrence of reddish-brown colour of the medium- to coarse-grained stream sediment lenses in the middle portion of the profile indicates that the oxidation of iron oxyhydroxides was

most likely caused by their sub-aerial exposure. These processes suggest the occurrence of strong variations in the flow regime of the fluvial system or lowering of the water table for a prolonged period of time.

Figure A4.4. Landscape photograph of the meandering Río del Oro (River of Gold) close to the floodplain sediment profile JP-759 looking towards a north-easterly direction. The outer part of the meander undercuts the bank and exposes good floodplain sediment sections for sampling as can be seen in Figure A4.5. Directly opposite the cut bank, on the inside lobe of the meander, there is deposition of a point bar. Photograph by Carlos Johnson (SNGM).

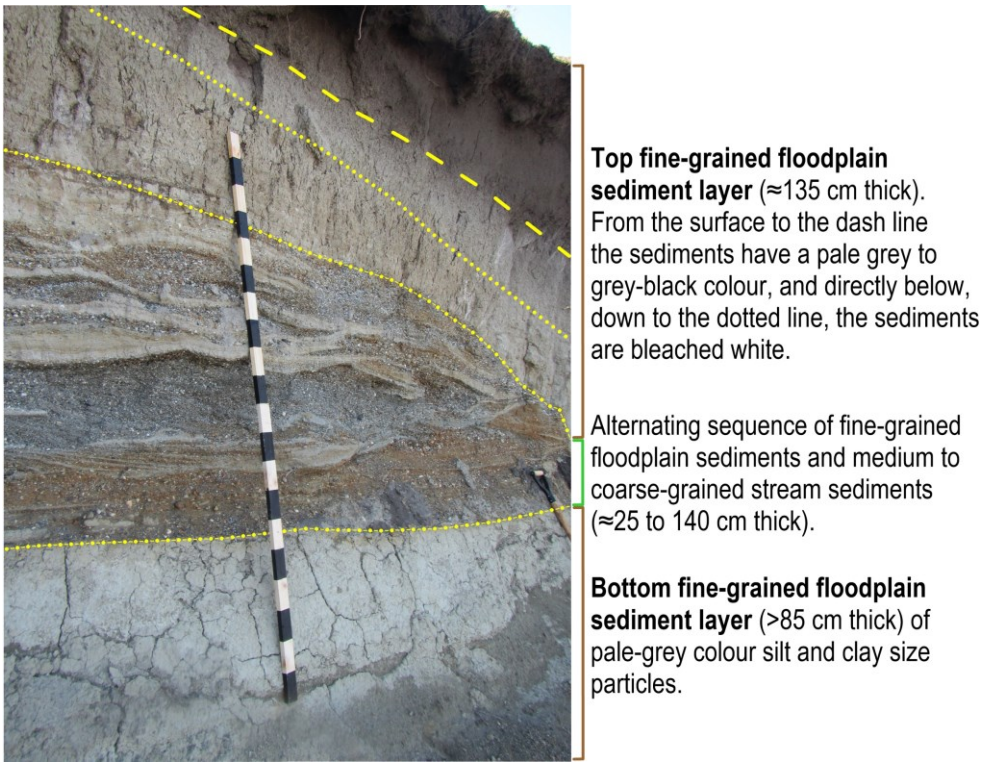


Figure A4.5. Field site JP-759. Close-up photograph of the floodplain sediment profile. The alternate colour wooden scale-bar is divided into 10 cm sections. Photograph by Felipe Astudillo (SNGM).

The top and bottom floodplain sediment layers as observed in the studied profile are suitable for conducting geochemical sampling. Further, fine-grained active stream sediment is available, and, of course, stream water (Figure A4.4).

In logistical terms, this sector does not present access difficulties. It is relatively closed to Cerro Sombrero, an important logistics centre, where there is the possibility of spending the night (management of prior permits from Empresa Nacional del Petróleo – National Petroleum Company), provisioning and refuelling.

A4.3.2. Field site JP-760: Residual soil

This field site is located approximately 32 km to the south-east of the Parador Rusffin locality. The general topography is shown in Figure A4.6. A pit was dug to study the Cambisol soil profile, according to the classification of the Harmonised World Soil Data Base (FAO/IIASA/ISRIC/ISS-CAS/JRC, 2009). The residual soil is developed on glacial till deposited over EM1m (Eocene-Miocene) coastal marine sedimentary sequence (Figure A4.2).

The exposed soil profile has a thickness of approximately 125 cm (Figure A4.7). The A horizon is dark grey to grey-black colour, and the upper part of the B horizon (whitish colour) corresponds to the typical appearance of a soil affected by gleisation. This process indicates the occurrence of remobilisation of chemical elements and fixation of Fe and Mn due to reducing conditions, associated with water saturation with little exchange rate. These reducing conditions most likely have affected the upper part of this glaciofluvial deposit, and the textural features are better preserved in the C horizon.

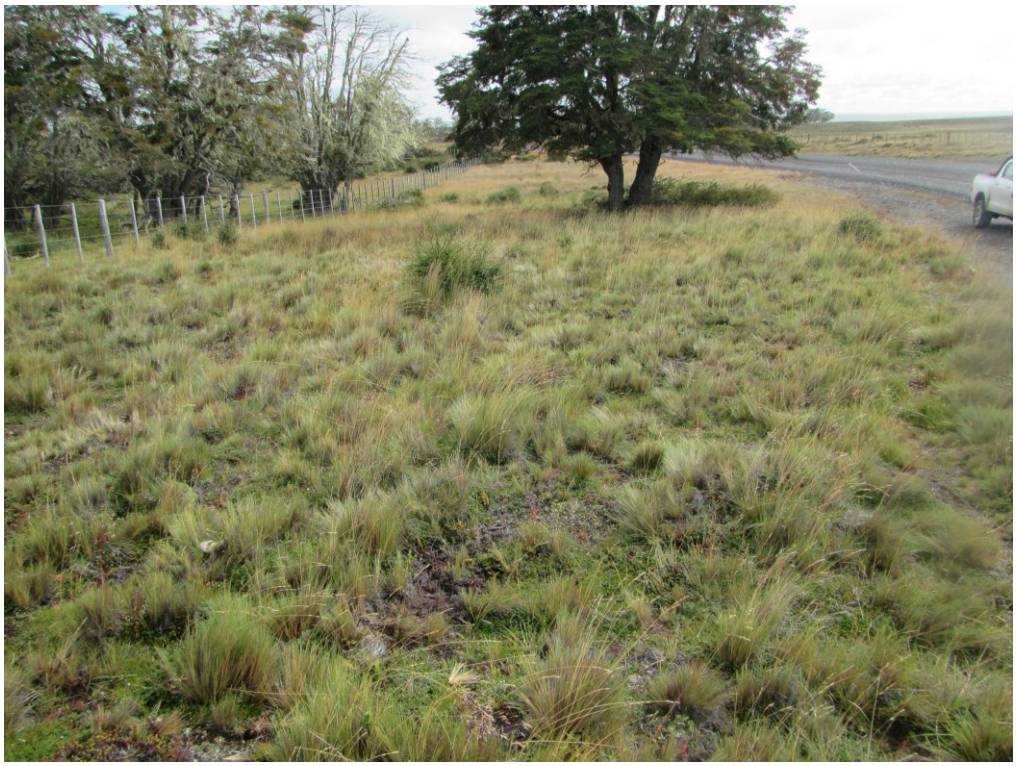


Figure A4.6. Field site JP-760. Landscape photograph (see Figure A4.6 for soil profile). Photograph by Juan Lacassie (SNGM).

This residual soil profile is suitable for the collection of top and bottom soil samples from the A and C horizons, respectively.

In logistical terms, it was observed that this sector is characterised by fenced private properties, which makes access difficult. It is necessary, therefore, prior to the geochemical

survey campaign, to contact the property owners and obtain their permission. The best approach is to contact the respective local government for a list of names and telephone numbers.

In this area, the closest logistics centre is Parador Rusfinn, where it is possible to spend the night and refuel (diesel). It is recommended to book in advance (contact telephone number available on the internet) to verify accommodation availability.

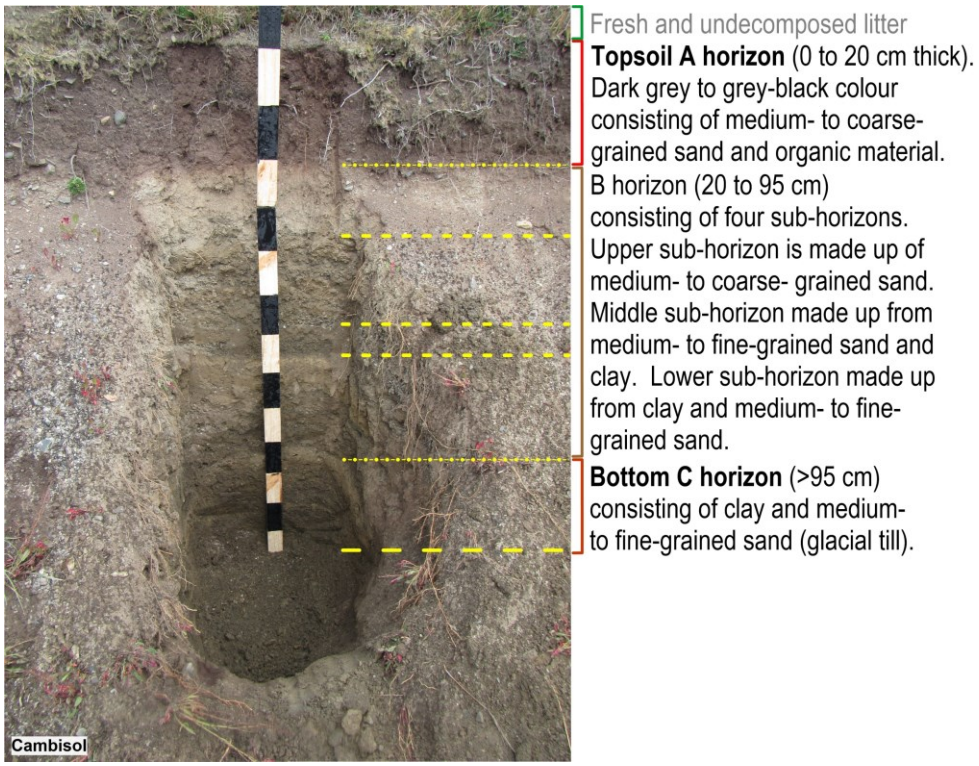


Figure A4.7. Field site JP-760. Close-up of the Cambisol soil profile. The alternate colour wooden scale-bar is divided into 10 cm sections. Photograph by Juan Lacassie (SNGM).

A4.3.3. Field site JP-761: Overbank sediment

This field site is located approximately 4 km south of Lake Fagnano, adjacent to the route that goes to Yendegaya (road under construction). At this point, the exposed bank was cleared in order to study the profile of the fluvial deposits of the second order river that drains this valley (Figures A4.3 & A4.8), and which have been deposited on the marine sedimentary sequences (limestone, shale, calcareous sandstone, sandstone and coquinas) of unit JK1m (Figure A4.2).

The exposed overbank sediment profile has a thickness of approximately 150 cm (Figure A4.9). The profile, as a whole, from the very bottom to the surface, represents a transition from a very low-energy environment (inundated floodplain phases) to a medium- to a high-energy environment as indicated by the large pebbles and cobbles on the surface and the tree trunk, as well as the pebbles deposited in the erosion hollow, which is indicated by the red dotted-line in Figure A4.9.

The exposed overbank sediment profile shows that there are suitable top and bottom layers for sampling as displayed in the annotated photograph of Figure A4.9. Fine-grained active stream sediment is also available for sampling, and, of course, stream water (Figure A4.8).

In logistical terms, it was observed that this sector does not present access difficulties due to the absence of fences round private properties. The closest logistics centre is Caleta María, which is situated at the mouth of the Azopardo River. Here, there is accommodation and a pansion. Alternatively, Mr. Germán Genkowsky, one of the first settlers from Lago Fagnano, has cabins for tourists, located on the north-east shore of Lake Fagnano. It is recommended to

FIGURE A4.8. Field site JP-761. Landscape view looking to the south of the fluvial valley, which is parallel to the route that connects Lago Fagnano with Yendegaya (see Figure A4.3). The studied overbank sediment profile is on the right-hand side of the photograph below the tree trunk (Figure A4.9). The comparatively large pebble and cobble deposits in the river valley suggest that during flood events a heavy load is transported. Behind and in front of the triangular pebble-cobble bar there are fine-grained stream sediments. The source of the catchment basin in the far background reaches the summits of the mountain range, which is covered by glaciers and their respective proximal moraine deposits. Abundant transported tree trunks occur over both the proximal and distal terraces. Photograph by Felipe Astudillo (SNGM).

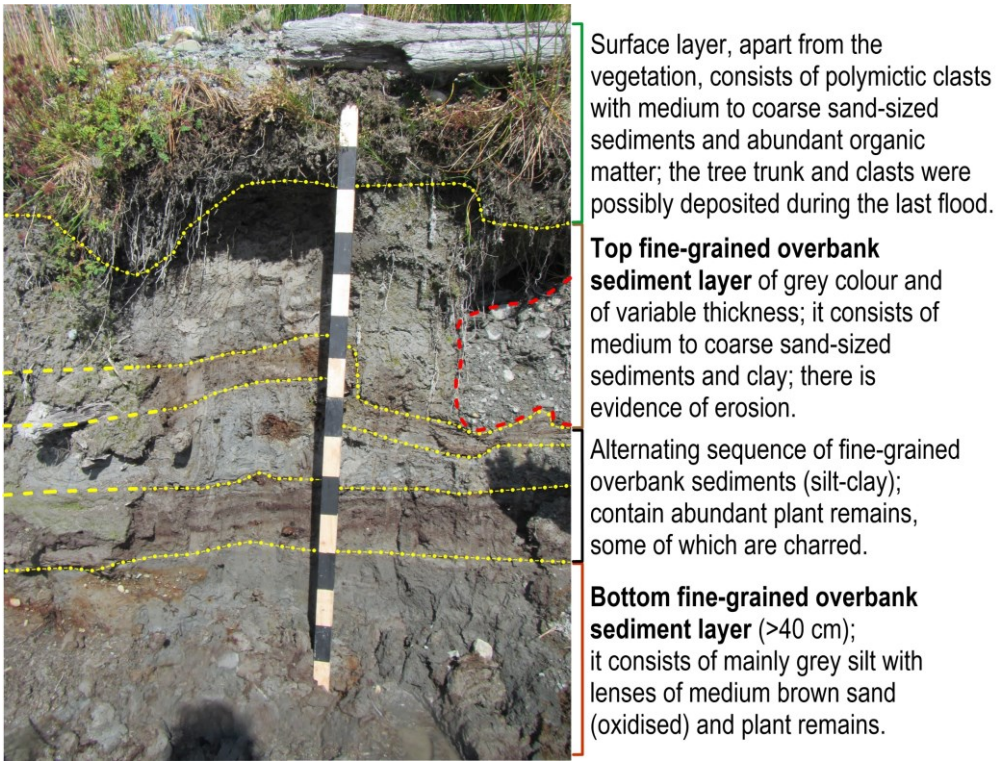


Figure A4.9. Field site JP-761. Close-up of the overbank sediment profile. The alternate colour wooden scale-bar is divided into 10 cm sections. The red dotted-line marks an erosion hollow and deposition of polymict clasts (pebbles-sand-silt). Photograph by Felipe Astudillo (SNGM).

previously make the pertinent contacts by telephone (telephone available on the internet by 'Cabañas Genkowsky'). However, the closest sector to refuel is located in Parador Rusfin (approximately 100 km to the north). Because of the rather difficult conditions, it is strongly recommended to carry extra fuel stored in certified tanks.

A4.3.4. Field site JP-762 and JP-763: Rock outcrops

Field sites JP-762 and JP-763 are located, respectively, 8 and 12 km south of Lake Fagnano (Figures A4.1, A4.2 & A4.3). Both are situated adjacent to the route to Yendegaya (road under construction). In particular, site JP-763 lies at the advance front of the road under construction.

At these sites, soil and sediment profiles were not studied, but rather observations were made for the occurrence of outcrops, which are present on the slope adjacent to the road.

Along this road, there are outcrops of slightly weathered rock, which are almost devoid of vegetation. At both sites there are outcrops of marine sedimentary strata, composed of sandstone and black shale, corresponding to the littoral or platform marine sedimentary sequences of unit JK1m (Figure A4.2).

At site JP-762 there is an outcrop of black bituminous shale with abundant disseminated pyrite (probably of primary origin; Figure A4.10). At site JP-763, the contact between black shale and the intruded biotite granite is covered by fallen blocks of the latter (Figure A4.11).

In logistical terms, these two sites have the same characteristics as JP-761.

Figure A4.10. Field site JP-762. Outcrop of marine sedimentary strata composed of sandstone and black bituminous shale belonging to unit JK1m (Figure A4.2). Photograph by Juan Lacassie (SNGM).

A4.3.5. Field site JP-764: Residual soil

This site is located adjacent to route Y-895, and is 2 km south of the junction with the Ransmunssen River. At this point, a pit was dug to study the soil profile in a glaciofluvial plain developed on the marine and paralic sedimentary sequences (sandstone and shale) of the Ks1mp unit (Figures A4.2, A4.12 & A4.13).

Figure A4.11. Sample site JP-763. Photograph was taken at the front of the road that connects Lake Fagnano and Yendegaya (road under construction). The presence of granite blocks derived from the erosion of outcrops of this rock in Cordillera Darwin are observed. The granite intrudes (contact covered by debris) the black shale of the JK1m unit. Felipe Astudillo on the left and Juan Lacassie Reyes on the right. Photograph by Carlos Johnson (SNGM).

Figure A4.12. Field site JP-764. Pit dug in glaciofluvial deposits on the side of road Y-895. Part of the glacial relief that characterises this plain is observed at the distance. Photograph by Juan Lacassie (SNGM).

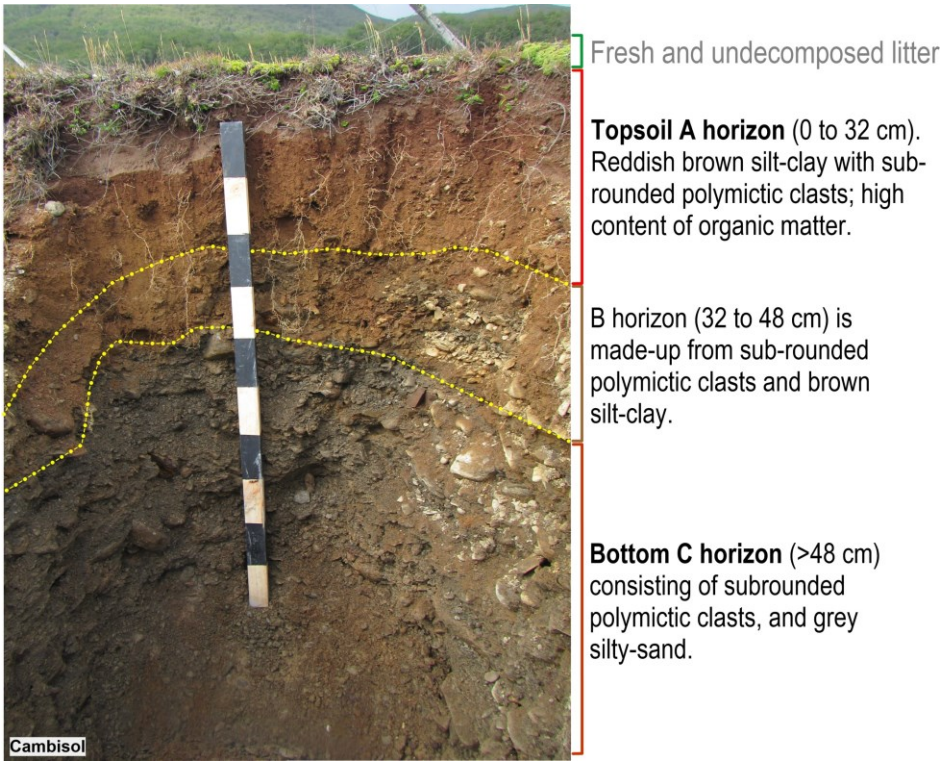


Figure A4.13. Sample site JP-764. Close-up photograph of the residual soil profile developed on glaciofluvial deposits. The alternate colour wooden scale-bar is divided into 10 cm sections. Photograph by Felipe Astudillo (SNGM).

The exposed residual Cambisol soil profile has a thickness of approximately 100 cm (Figure A4.13), which is located in a first-order catchment basin (Figure A4.3). The entire profile is made up of the same type of glaciofluvial deposit. The A horizon contains a higher proportion of organic matter (roots), and has been affected by a greater degree of chemical weathering (reddish-brown colouration). The original characteristics of the deposit are better preserved below a depth of 48 cm. At this level, the glaciofluvial deposit consists of sub-rounded polymictic clasts without gradation. Hence, at this site the soil profile is developed on a glaciofluvial deposit (till), and is consistent with the glacial geomorphology of the area (Figure A4.12).

This residual soil profile, developed on glaciofluvial deposits, is suitable for the collection of top and bottom soil samples from the A and C horizons, respectively.

In logistical terms, this sector has fenced properties, which greatly limit geochemical sampling. Hence, prior to the geochemical survey campaign, it is necessary to make contacts and obtain permits from the property owners. It is, thus, recommended to approach the respective local governments, which have a list of telephone contacts.

A4.3.6. Field site JP-765: Overbank sediment

This site is located adjacent to road Y-895 at its northernmost junction with Ransmunssen River, a second order magnitude stream (Table A4.1). In this sector, the streams drain to a low gradient glaciofluvial plain. Accordingly, the river meanders and on its banks there are exposures of overbank sediment deposits (Figure A4.14). The observed deposits coincide with the expected fluvioglacial and deltaic deposits associated with the Q1 unit (Figure A4.2).

The exposed profile has a thickness of ≈170 cm (Figure A4.15). The upper surface and bottom layers are medium-energy fluvial deposits, with sedimentary structures (e.g., imbrication). In contrast, the central part of the profile presents two low-energy fine-grained

Figure A4.14. Field site JP-765. The exposed overbank sediment bank on Ransmunssen River is adjacent to its junction with route Y-895. The bank was cleared to expose the overbank sediment sequence, and a pit dug down to the bedload deposit. Photograph by Juan Lacassie (SNGM).

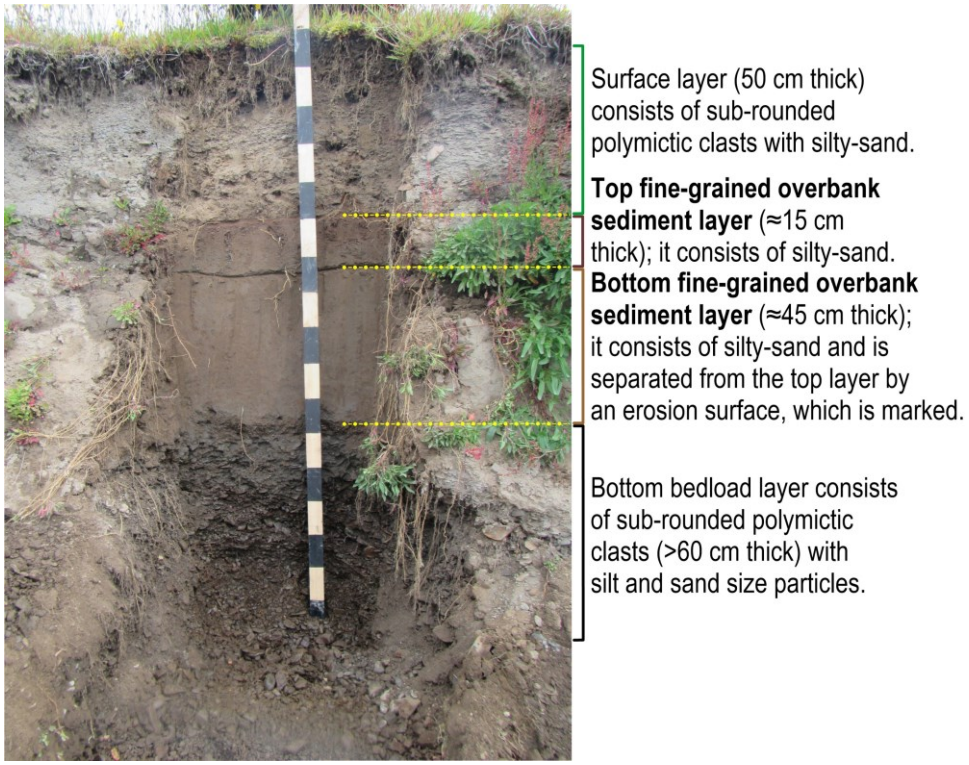


Figure A4.15. Field site JP-765. Close-up photograph of overbank sediment profile. The alternate colour wooden scale-bar is divided into 10 cm sections. Photograph by Juan Lacassie (SNGM).

overbank sediments, with homogeneous characteristics, which probably correspond to two successive flood events.

The studied overbank sediment profile, as well as the adjoining floodplain, present ideal conditions for conducting geochemical sampling.

In logistical terms, this sector does not present access difficulties. However, along the entire Y-895 route, the existence of fences prevent access to private properties. It is, thus, necessary to obtain access permits from the property owners prior to the geochemical survey.

A4.3.7. Field site JP-766: Overbank sediment

This site is located near the bridge over the Río Chico on route Y-895. In this sector, the second order river flows over a low gradient glaciofluvial plain (Table A4.1; Figure A4.16), which lies over a transgressive platform of marine sedimentary sequences (fine-grained sandstone, claystone and siltstone) of unit M1m (Figure A4.2).

The studied profile (Figure A4.17) shows a succession of low-energy overbank sediment layers, which are the result of successive flood events that covered the alluvial plain. The grey colour bottom overbank sediment layer denotes reducing conditions. The overlying layer has a reddish-brown colour indicating exposure to subaerial conditions (oxidation of iron oxyhydroxides). The observed redox features suggest the occurrence of strong variations in the fluvial conditions as, for example, inundation of the floodplain or decrease in the water table level for prolonged periods.

The studied overbank sediment layers present ideal conditions for carrying out geochemical sampling. Samples of stream sediment and stream water can also be collected.

In logistical terms, this sector does not present access difficulties. However, along the entire Y-895 route, the existence of fences prevents free access to private properties. For this reason, in this sector, along the Y-895 route, it is necessary to obtain access permits prior to the geochemical survey.

Figure A4.16. Field site JP-766. Landscape photograph showing overbank sediments on the outside meander bank, and a pebble-cobble bar on the inside bend (see Figure A4.17 for profile). The flat, low gradient slope morphology of the floodplain is observed. Photograph by Juan Lacassie (SNGM).

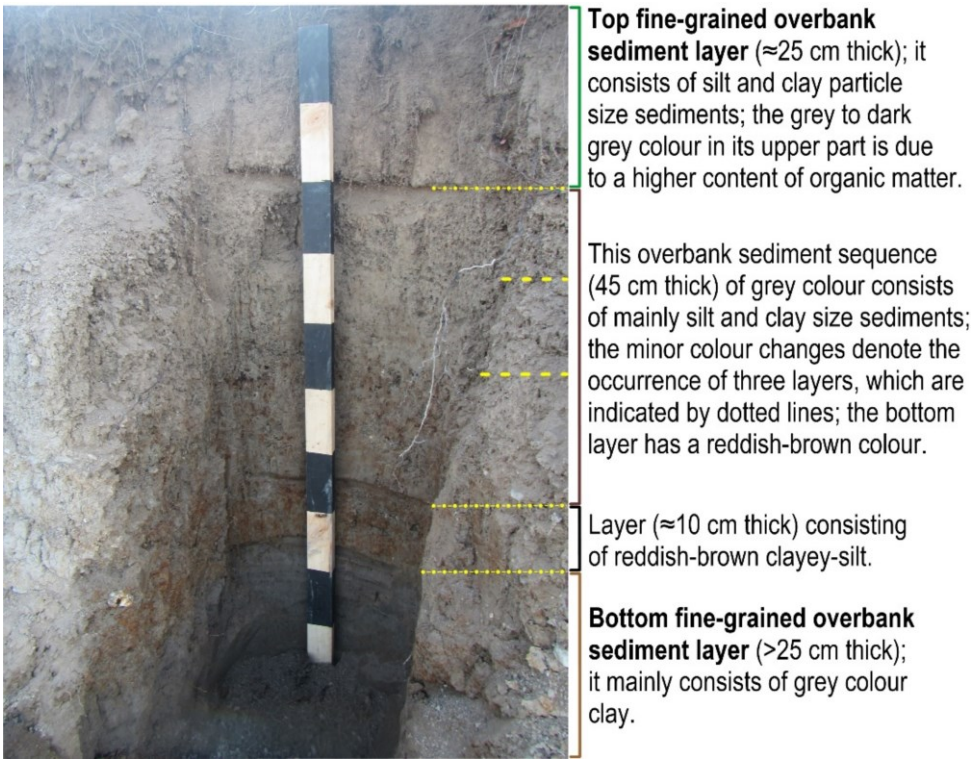


Figure A4.17. Field site JP-766. Close-up of the overbank sediment profile on Río Chico. The alternate colour wooden scale-bar is divided into 10 cm sections. Photograph by Felipe Astudillo (SNGM).

A4.4. CONCLUSIONS AND RECOMMENDATIONS

The visited catchment basins present ideal conditions for geochemical sampling of all sample types, *i.e.*, stream sediment, stream water, overbank sediment, residual soil and rock from second order streams, and floodplain sediment from third or higher order streams.

The following conclusions and recommendations are made, based on the recorded observations of the Tierra del Fuego reconnaissance survey:

- Extensive floodplains are available, and the different levels of deposition are accessible for sampling either by digging pits or clearing exposed river/stream bank sections.
- The rivers and streams transport polymictic medium to fine-grained sediments, suggesting distal provenances. Thus, their chemical composition can be used to define a regional scale baseline and to delineate prospective zones for mineral exploration.
- Glaciofluvial deposits display limited soil development. This reflects a low degree of chemical weathering, so the chemical composition of these deposits can be used for prospective purposes.
- In the cases, where gleisation and reddish-brown oxidation occurs, it is recommended to avoid sampling these levels as there is the possibility of remobilisation of chemical elements and alteration of the original composition.
- In the southern part of the area (*e.g.*, Lago Fagnano), the topographic relief presents a greater development, and it is possible to find rock outcrops of sedimentary sequences of sandstone and shale. At some points, the shale is bituminous (site JP-762), while at the end of the road under construction to Yendegaya, these rocks were intruded by granite (site JP-763).
- Stream sediment and stream water samples can also be collected.

In terms of logistics, the following were verified:

- The streams and rivers of interest can be accessed mostly at the intersection with roads and paths. To carry out the geochemical sampling, access permits to private properties are required.
- It is not recommended to operate using camps, due to adverse weather conditions, mainly wind and rain. The available accommodation is variable and can be adjusted to the usual budget restrictions. However, it was verified that there are few logistics operation centres, where it is possible to stay, purchase groceries and fuel. It is, therefore, crucial to make a good plan before starting the field campaign. In particular, due to the scarcity and distance of refuelling stations, it is necessary to carry extra fuel in certified fuel tanks.

A4.5. REFERENCES

Darnley, A.G., Björklund, A., Bølviken, B., Gustavsson, N., Koval, P.V., Plant, J.A., Steenfelt, A., Tauchid, M., Xuejing, Xie., Garrett, R.G. & Hall, G.E.M., 1995. *A Global Geochemical Database for Environmental and Resource Management. Recommendations for International Geochemical Mapping – Final Report of IGCP Project 259*. Earth Science Report 19. UNESCO Publishing, Paris, 122 pp.; https://globalgeochemicalbaselines.eu.176-31-41-129.hs-servers.gr/datafiles/file/Blue_Book_GGD_IGCP259.pdf.

Li, Y., Zhang, H., Tua, C., Song, F., Luo, Y., 2017. *Occurrence of red clay horizon in soil profiles of the Yellow River Delta: Implications for accumulation of heavy metals*. Journal of Geochemical Exploration, 120-127; https://doi.org/10.1016/j.gexplo.2015.11.006.

FAO/IIASA/ISRIC/ISS-CAS/JRC, 2009. Harmonized World Soil Database (version 1.1). FAO, Rome, Italy and IIASA, Laxenburg, Austria, 43 pp.; http://www.fao.org/3/aq361e/aq361e.pdf.

Salminen, R., Tarvainen, T., Demetriades, A., Duris, M., Fordyce, F.M., Gregorauskiene, V., Kahelin, H., Kivisilla, J., Klaver, G., Klein, P., Larson, J.O., Lis, J., Locutura, J., Marsina, K., Mjartanova, H., Mouvet, C., O'Connor, P., Odor, L., Ottonello, G., Paukola, T., Plant, J.A., Reimann, C., Schermann, O., Siewers, U., Steenfelt, A., Van Der Sluys, J. & Williams, L., 1998. *FOREGS Geochemical Mapping Field Manual*. Geological Survey of Finland, Espoo, Guide 47, 36 pp.; http://tupa.gtk.fi/julkaisu/opas/op_047.pdf.

SERNAGEOMIN, 2002. *Mapa Geológico de Chile. Servicio Nacional de Geología y Minería, Carta Geológica de Chile, No. 751 mapa en tres hojas, escala 1:1,000,000*. Santiago.

Strahler, A.N., 1969. *Physical Geography*. John Wiley & Sons, Inc., New York and London, 733 pp.

APPENDIX 5: REGIONAL REPORTS

A5.1. AFRICA

Report by Theophilus C. Davies (Mangosuthu University of Technology, KwaZulu Natal, South Africa; theo.clavellpr3@gmail.com)

During 2020, field sampling activities, laboratory analyses, data interpretation and training workshops relevant to the '*Africa Geochemical Database Programme*' were limited. Most of the activities were published, and included in the following publications and webinars:

1. Nforba, M.T., Egbenchung, K.A., Berinyuy, N.L., Mimba, M.E., Tangko, E.T. & Nono, G.D.K., 2020. *Statistical evaluation of stream sediment geochemical data from Tchangue-Bikoui drainage system, Southern Cameroon: A regional perspective*. Geology Ecology and Landscapes, 13 pp.; https://doi.org/10.1080/24749508.2020.1728023.

   Summary: '*Stream sediments play a significant role in geochemical exploration by identifying possible sources of anomalous element concentration*.' In this study, the researchers used multi-element association analysis to investigate the concentration of gold and associated elements in stream sediment samples from the Tchangue-Bikoui drainage area, Southern Cameroon.

2. Bam, E.K.P., Akumah, A.M. & Bansah, S., 2020. *Geochemical and chemometric analysis of soils from a data scarce river catchment in West Africa*. Environmental Research Communications 2(3), 18 pp.; https://doi.org/10.1088/2515-7620/ab59c6.

   Summary: In this study, 49 high-resolution soil cores were obtained from three vertical profiles in the Densu River Basin of Ghana and the concentrations of major and trace metals (Ca, K, Fe, Ti, Cr, Cu, V, Ni, and Zn) measured. The aim was to examine and provide data on metal levels to serve as baseline information on mobilisation studies for waste management. Geochemical methods for estimation of metal enrichment and accumulation were employed to determine enrichment and pollution, sources, and mobilisation of the metals.

3. Twigg, H. & Hitzman, M., 2020. *Lithostratigraphic mapping through saprolitic regolith using soil geochemistry and high-resolution aeromagnetic surveys*. Abstract, EGU General Assembly 2020, Online, 4 - 8 May 2020. EGU2020-20242; https://doi.org/10.5194/egusphere-egu2020-20242.

   Summary: The researchers showed how the use of multielement soil geochemistry can provide a means for conducting geological mapping in the Neoproterozoic Central African Copperbelt [Democratic Republic of the Congo (DRC)]. Areas with outcrops or those containing drill holes and/or trenches were utilised to relate known geological lithologies with soil geochemical results using major element and trace element ratios.

4. The Project: '*Strengthening African capacity in soil geochemistry to inform agriculture and health policies*', funded by the Royal Society's Department for International Development (RS-DFID) Africa Capacity Building Initiative, Round 1 was in an active state; https://royalsociety.org/grants-schemes-awards/grants/dfid-broadley-watts/

The aim of this project was to strengthen research capacity in soil geochemistry in Sub-Saharan Africa. The Project began in 2015 and was terminated in 2020.

5. Report by Mark Ferguson, 2020. *Arbor Metals Completes Geochemical Programme at Rakounga Gold Project, Burkina Faso, West Africa*, TSX VENTURE: ABR. https://www.juniorminingnetwork.com/junior-miner-news/press-releases/2777-tsx-venture/abr/86396-arbor-metals-completes-geochemical-program-at-rakounga-gold-project-west-.

   Summary: On the 23rd of October, 2020 Arbor Metals Corp. (TSXV:ABR), (FWB:432, Vancouver, Canada, announced the completion of its recent soil grid geochemistry programme at the 250 km^2 Rakounga Gold Project, located in Burkina Faso, West Africa.

   The 55-line kilometre soil geochemistry programme was designed to extend the geochemical gold anomalies identified in 2019 and to test for continuity of these geochemical gold trends extending from the neighbouring Bouboulou permit, which borders the Rakounga permit on the north. The soil programme collected a total of 779 samples at fifty metre stations on lines spaced 200 metres apart (Figure A5.1). Soil samples were collected from depths which averaged 50 cm below the surface.

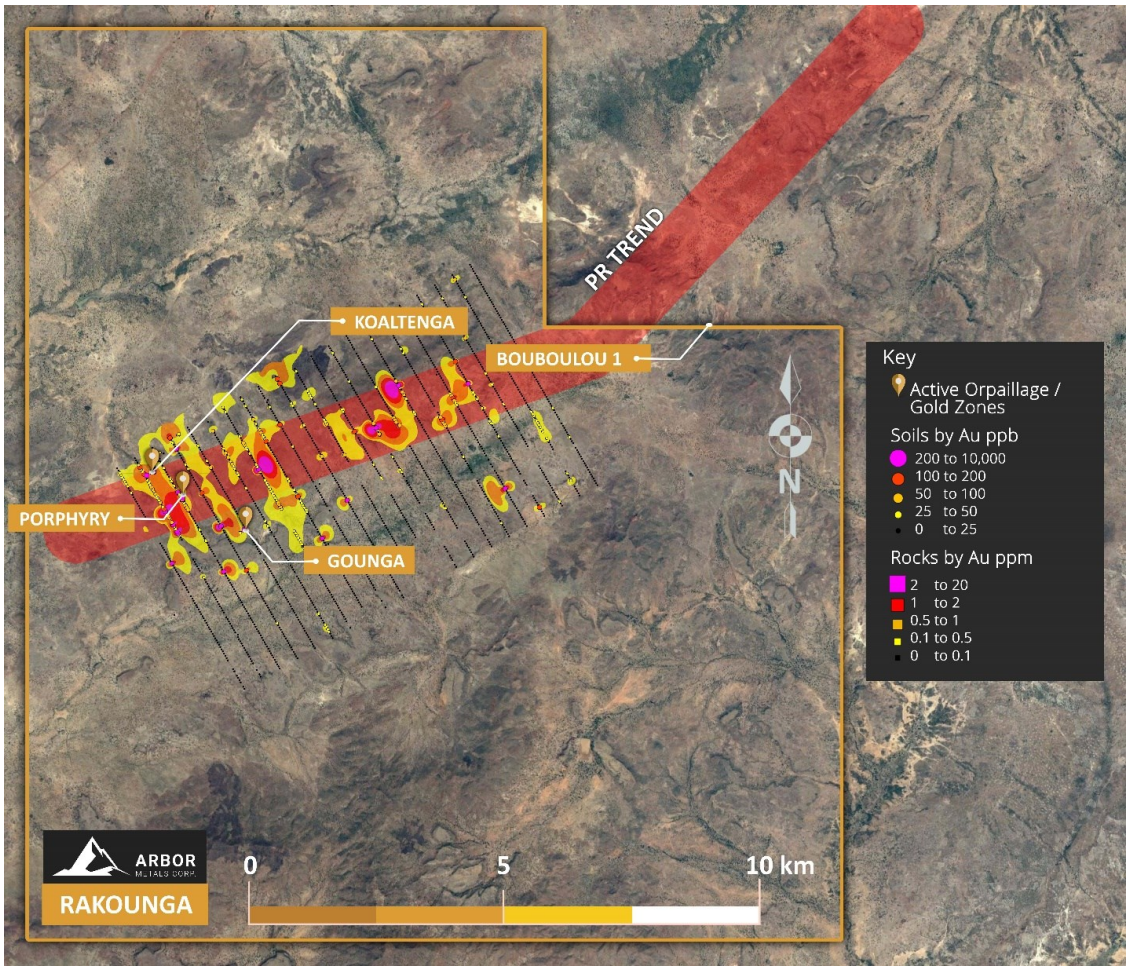


Figure A5.1. Rakounga gold concession, existing PR Gold Trend, showing gap towards the Bouboulou 1 orpaillage, Burkina Faso, West Africa. Source: https://www.thenewswire.com/data/tnw/clients/img/e34daddeb43a9dc4acd2dd5b98d881b7.png

6. Scott Halley (Webinar, 3rd June 2020). Geochemical methods and datasets. https://www.alsglobal.com/en/myals/events/2020/6/geochemical-analyses-for-mapping-geological-processes-africa-webinar.

   Summary: '*Advancement in ICP-MS technology has resulted multi-element geochemistry methods with detection levels below or close to crustal abundance. The routine use of these methods now produces data sets rich with information, but the results are often underutilised due to what can be an overwhelming amount of data*.' This 'Webinar' provided tools for geologists to make the most of these large geochemical data sets, and included:

   - Discussion of analytical methods and QA/QC.
   - Multi-element workflow, along the lines of Scott's recent SEG paper.
   - Case study: CODES AMIRA Copperbelt project data.

A5.2. AMERICA, NORTH

A5.2.1. Mexico

In 2019, the Mexican Geological Survey partially finalised and internally delivered three atlases with information compiled and interpreted from the results of the 3,509 chemically analysed samples in the Survey's laboratories. In 2020, the data are still under validation, and because of the Covid-19 pandemic, there was not much time to complete the whole process.

A web application will be developed to access the information of the three geochemical atlases.

A5.2.1.1. Atlas of potential hazardous elements in Mexican soil

Twelve of the more potential hazardous elements (PHEs) were considered, namely As, Ba, Be, Cd, Cr, Hg, Ni, Ag, Pb, Se, Tl and V. Their spatial distribution is useful in identifying concentrations of these potentially hazardous elements to human health. In the report, several considerations are made regarding the spatial distribution and possible relationship between these elements and regions of Mexico. A full report will be released next year.

A5.2.1.2. Rare earth element content in Mexican soil

In a broad sense, this atlas will present all the detailed information about the project, maps and diagrams of rare earth elements contained in the soil of the Mexican Republic in a low sampling density sampling of 1,600 km^2 grid cells.

A5.2.1.3. Elements in soil useful for economic geology

This Geochemical Atlas with 21 elements of interest to economic geology will include information on the spatial distribution, regional content and concentrations of Li, Rb, Cs, Sr, Ti, Nb, Ta, Mo, W, Mn, Re, Fe, Cu, Zn, Ga, Sn, Sb, Bi, Th and U in the sampled soil horizons. They will be used as pathfinders for the location of mineralisation.

A5.2.2. United States of America

Report by David B. Smith (United States Geological Survey; dbsmith13@gmail.com)

In 2020, the U.S. Geological Survey published a paper about the analytical methods, which were used to determine the elemental concentrations in the stream sediment geochemical data set for Alaska. The complete reference is:

Wang, B., Ellefsen, K.J., Granitto, M., Kelley, K.D., Karl, S.M., Case, G.N.D., Kreiner, D.C. & Amundson, C.L., 2020. *Evaluation of the analytical methods used to determine the elemental concentrations found in the stream geochemical dataset compiled for Alaska*. U.S. Geological Survey Open-File Report 2020-1038, 66 pp.; https://pubs.usgs.gov/of/2020/1038/ofr20201038.pdf.

A5.3. AMERICA, SOUTH

A5.3.1. Brazil

Report by Otavio Augusto Boni Licht (Federal University of Paraná, Earth Sciences Sector; otavio.licht@gmail.com)

During 2020 the geochemical team of the Geological Survey of Brazil (CPRM) worked on the planning of fieldwork and sampling activities for the development of the Global Geochemical Baselines project in Brazil. The team has been working according to the guidelines provided by the International Centre on Global-Scale Geochemistry (ICGG), in China, and according to discussions held with Dr. Alecos Demetriades, Chairperson of the Commission's Sampling Committee.

This work will result in a Work Plan to be executed throughout the country, within an area of about 8,500,000 km^2, which will be presented to the Executive Board of CPRM for approval. Once approved, it will be sent to the ICGG and China Geological Survey to conclude a Cooperation Agreement. CPRM and CGS have a MoU and have been working on scientific cooperation projects since 2016; this should facilitate negotiations for the implementation of the Geochemical Baselines Project in Brazil.

On the other hand, CPRM and the Colombian Geological Survey (SGC) are already discussing the sampling work in the border region between Brazil and Colombia in the Amazon region. This will be an overly complex task for both Brazilian and Colombian researchers.

Figure A5.2 shows Brazil and its 410 grid cells (160x160 km) and 1720 random samples. Our geochemists are working on planning and logistical details of the sampling so that we have the entire country covered.

At the same time, CPRM has been developing geochemical mapping projects at different scales. Due to the Covid-19 pandemic, these projects had their fieldwork paralyzed and should be resumed in 2021.

In 2020, through the Association of Iberoamerican Geological and Mining Surveys (ASGMI), CPRM met with Geological Surveys from Latin American countries (and Portugal and Spain) to develop Geochemistry in our continent. At these meetings we have been working for a better dissemination of Geochemistry and Geochemical Mapping projects and in the preparation of the Sampling Manual to be used in the Global Geochemical Baselines project.

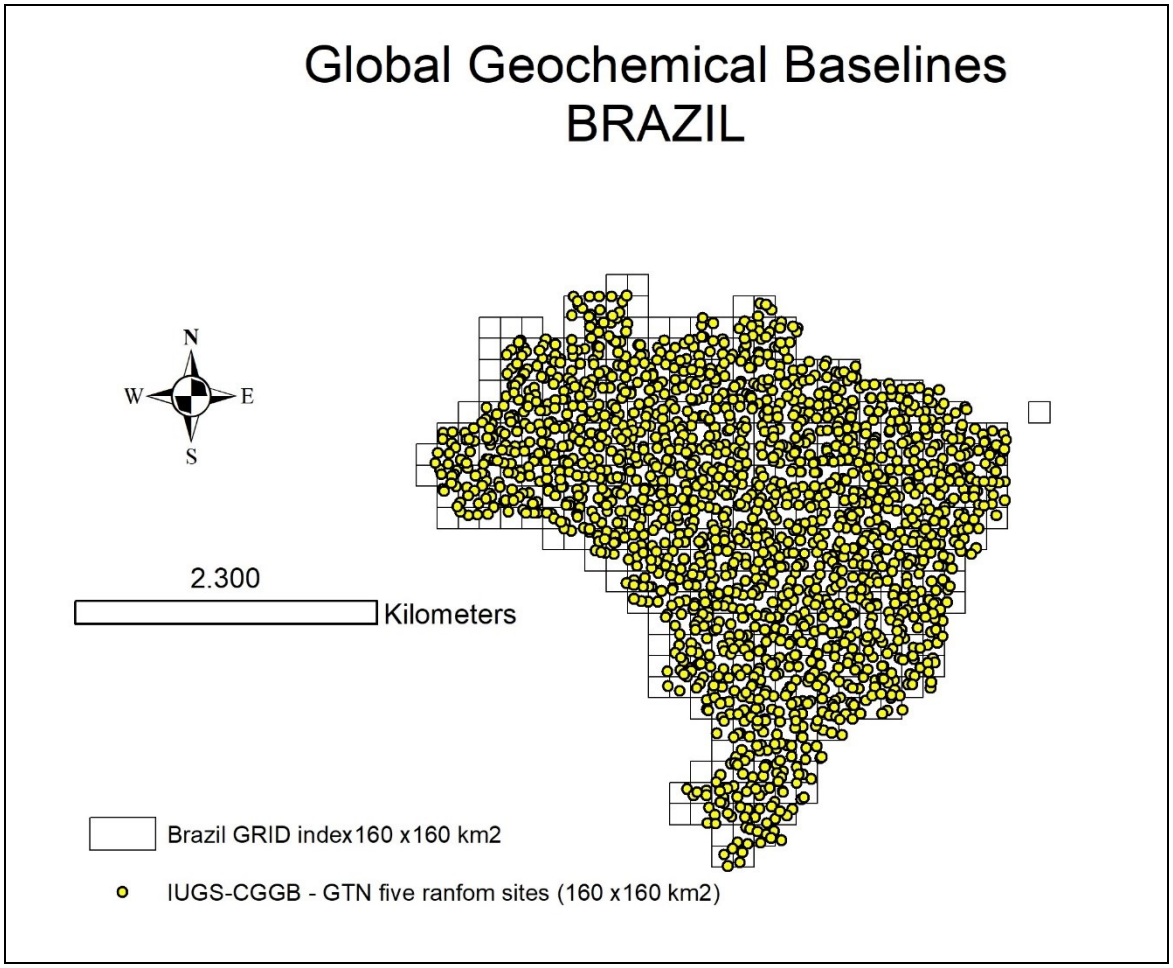


Figure A5.2. Global Terrestrial Network grid cells of 160x160 km with random sampling sites in Brazil.

A5.3.2. Chile

Report by Juan Pablo Lacassie Reyes (Chief Geologist-Unit of Geochemistry, Geological and Mining Survey of Chile (SERNAGEOMIN); juan.lacassie@sernageomin.cl)

A5.3.2.1. General information

The Geochemical Map of Chile is a Government programme, which is carried out by the Geological and Mining Survey of Chile (SERNAGEOMIN). The objective is to promote the sustainable growth of Chile by:

- The definition of geochemical baselines, and
- The identification of mineral resources.

From 2011-2020 the Government of Chile has provided funding for fieldwork, sampling, sample preparation, chemical analyses and staff salaries. The main project results of the 2019-2020 period are concisely described below.

A5.3.2.2. Geochemistry of the Huasco, Copiapó and Salado fluvial systems (1:250,000 scale)

The Huasco, Copiapó and Salado fluvial systems are the most important basins that concentrate the highest population and economic activity (mainly mining and agriculture) of the Atacama Region in northern Chile (Figure A5.3, zone A). As a result of the study of Sernageomin, a geochemical and mineralogical baseline has been defined for the first time for these basins.

In particular, the detailed geochemical data of the Salado and Copiapó fluvial systems, revealed the impact of recent alluvial deposits on the chemical composition of their sediments.

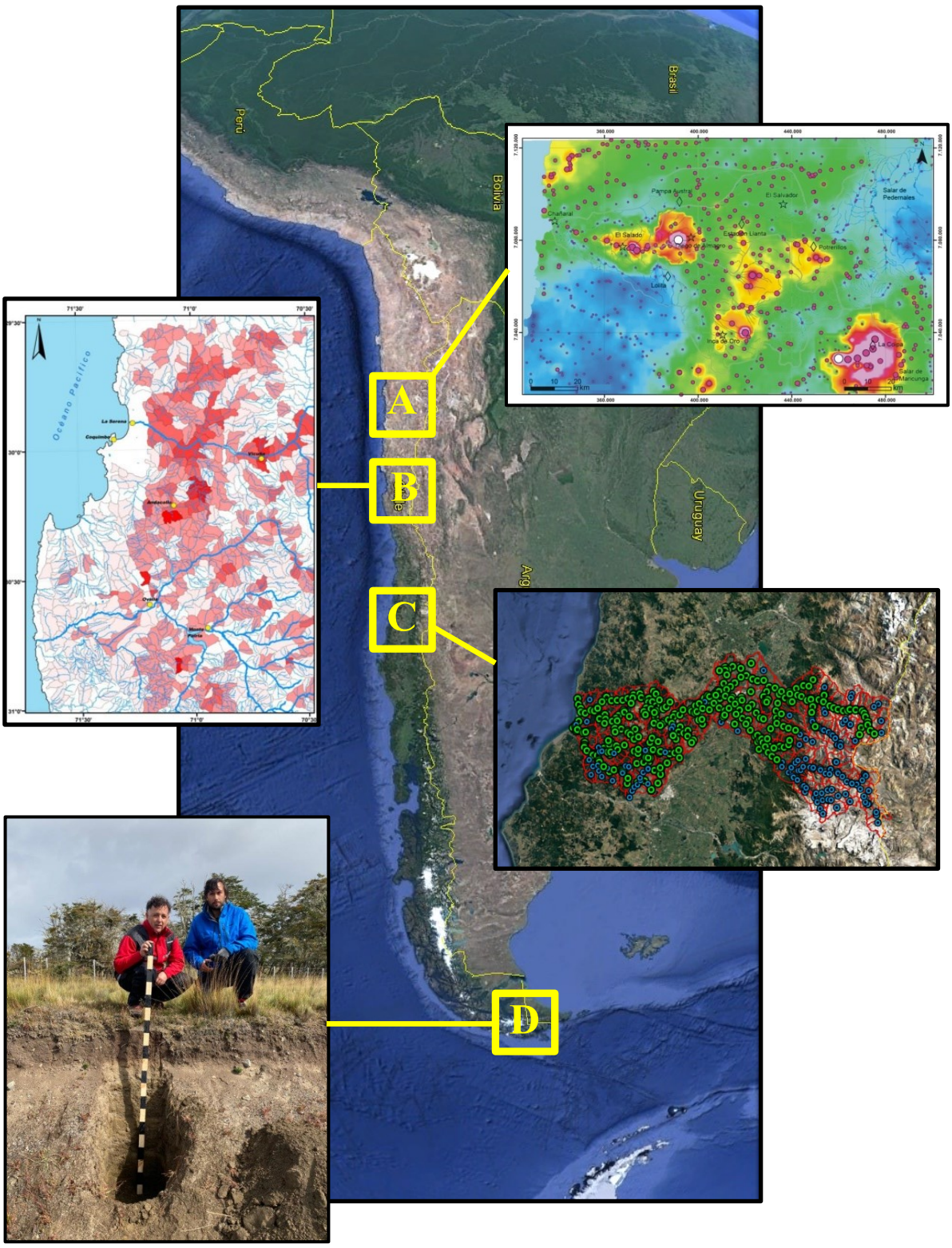


Figure A5.3. Geochemical Map of Chile (SERNAGEOMIN): Ongoing projects during the 2019-2020 period. A: Publication of geochemical studies of the Huasco, Copiapó and Salado river basins. B: Publication of the Geochemical Map of the La Serena Sheet. C: Ongoing geochemical sampling of the Mataquito River Basin (green and blue dots correspond to sampled and planned field points, respectively). D: Geochemical study of the sediments and soil of Tierra del Fuego (sub-Antarctic environment).

The results display important changes in the concentrations of As, Hg, Pb, Zn, Cd, Ni, Cr and Cu. The results also show the impact of mining activities including, tailings and processing plant wastes (Figure A5.4).

The results of these studies have been published in the following Technical Reports:

Lacassie J.P., Carrasco F. & Baeza B.L., 2019. *Impacto de las remociones en masa de marzo de 2015 en el sistema fluvial del Río Copiapó, Región de Atacama: análisis comparativo de la geoquímica de sedimentos* [monografías]. SERNAGEOMIN, Santiago, 84 pp.: il. (Informe Registrado: n.77); https://biblioteca.sernageomin.cl/opac/index.asp?param=o%AD%88%92bh%90%89rd%8A&Op=3.

Lacassie J.P. & Díaz, A., 2019. *Geoquímica y mineralogía de los sedimentos fluviales de la Cuenca del Río Huasco, Región de Atacama, Chile* [monografías]. : SERNAGEOMIN, Santiago, 81 h.: il. (Informe Registrado: n.71); https://biblioteca.sernageomin.cl/opac/index.asp?param=o%AD%88%92bp%99%89pd&Op=3.

Baeza L., Lacassie J.P. & Carrasco, F., 2020. *Impacto de las remociones en masa de marzo de 2015 en el sistema fluvial del río Salado, Región de Atacama: análisis comparativo de la geoquímica de sedimentos* [monografías]. SERNAGEOMIN, Santiago, 108 pp.: il. (Informe Registrado: n.82); https://biblioteca.sernageomin.cl/opac/index.asp?param=o%AD%88%92bh%90%8Bqd%88&Op=3.

A5.3.2.3. Geochemical Map La Serena Sheet (1:250,000 scale)

The Geochemical Map of the La Serena Sheet (Figure A5.3, zone B), presents the results of the analysis and processing of the concentrations of 61 elements and chemical compounds, for a total of 699 sediment samples distributed in the La Serena Sheet (Figure A5.5), which has a surface area of 16,218 km^2 and extends between 29°30'S and 31°00'S and from the coastline to 70°30'W.

For each element and compound, a map of point concentrations and another of catchment basins were generated, totalling 118 geochemical maps compiled in an interactive PDF format file, which includes additional layers of information that support visualisation and interpretation. These additional layers contain the basic geology of the map sheet, in addition to the location of the samples, delimitation of main hydrographic basins, topography, toponymy, road network, drainage network, location of active and abandoned mining sites, location of tailings deposits.

In addition, the chemical information was processed using different techniques, which, together with the interpretation of the geochemical maps, allowed the definition of regional to local geochemical patterns and anomalies. In particular, using box-and-whisker plots for the logarithmic transformed data, anomaly and atypical concentrations were defined for all elements and compounds in the database. Through comparative geochemistry between stream and river terrace sediments, it was possible to discriminate the natural, anthropic or mixed character of some anomalies. Using artificial neural network algorithms, it was possible to classify all samples into 6 groups (nodes) with similar chemical characteristics. The projection of these nodes on the map, allowed the recognition of regional geochemical patterns. These geochemical patterns were compared with those resulting from the projection of the anomaly indices for elements and compounds associated with sulphide and iron deposits.

Based on these results and the geochemical maps for the different elements and compounds, it was possible to identify 3 regional geochemical anomalies, coinciding with the Ferriferous Belt where regional anomalies of Fe-REE were identified, the Lower Cretaceous Copper

Porphyry Belt with regional Cu-S-Sb-Hg anomalies and the Upper Jurassic-Lower Cretaceous volcanic and sedimentary successions with regional Zn-As-Ba-Cs anomalies.

These results are planned to be published by the end of 2020 in the following product:

- Espinoza, F., Lacassie, J.P., Astudillo, F., Baeza, L., Castillo, P., Muñoz, N., Ramírez, C., Carrasco, F. & Miralles, C., 2020. *Geoquímica de sedimentos de drenaje de la Hoja La Serena, Región de Coquimbo*. Servicio Nacional de Geología y Minería, Carta Geológica de Chile, Serie Geoquímica.

Figure A5.4. Geochemical sampling of beach sediments at Chañaral bay in the Salado river fluvial system. The detailed photographs show that there are mineral precipitates (possibly as copper oxides) on the sand surface (greenish colour) and on the surface of seabird bones. This artificial beach resulted after more than 50 years of continuous discharge of mining tailings to the Salado river (Figure A5.3, zone A). Photograph by Juan Pablo Lacassie.

Figure A5.5. Geochemical sampling of stream sediments in the drainage system of the La Serena Sheet, in northern-central Chile (Figure A5.3, zone B). Photograph by Carolina Miralles.

A5.3.2.4. Geochemical sampling of the Mataquito fluvial system (1:250,000 scale)

The Mataquito basin covers an area of 5,400 km^2, with a population of approximately 1:50,000. It is one of the two main hydrographic systems of the Maule Region in central Chile (Figure A5.3, zone C).

In terms of climatology, this basin is located in the Mediterranean region of Chile (35°S), and in the transition zone between the semi-arid northern and the humid southern regions. Thus, the main economic activity is agriculture (12,7% of total basin acreage) which is concentrated in the Central Valley at the foothills of the Andes.

To the north and south of this basin there is conspicuous mining activity, concentrated along the Cretaceous belt of volcanoclastic rocks. However, this activity is not present in the Mataquito fluvial basin.

In 2019, Sernageomin started the study of this basin, with the following objectives:

1. to define a first geochemical and mineralogical baseline of this river basin;
2. to evaluate the presence of geochemical anomalies associated with mineralisation along the Cretaceous belt of volcanoclastic rocks.

Over 380 sample points have been planned to cover the entire surface of the basin. Up to date, the geochemical sampling has covered 80% of the basin area, which would be completed by March 2021. In this project a mobile phone application has been implemented to capture field data (Figure A5.6).

Figure A5.6. Geochemical sampling of stream sediments in the Mataquito river fluvial basin (Central Chile; Figure A5.3, zone C). The geologist Pablo Oliva is using a mobile phone application to capture field data (GPS location, pictures and field observations). Photograph by Juan Pablo Lacassie.

A5.3.2.5. Geochemical study of the sediments and soil in the sub-Antarctic environment of Tierra del Fuego, southern Chile

Between the 24th of February and 2nd of March 2020, a geological and logistical survey was carried out on the sub-Antarctic area of Tierra del Fuego, southern Chile (Figures A5.3, zone D & A5.7). Firstly, as a contribution to the Manual for Global Geochemical Sampling that is currently developed by the IUGS Commission on Global Geochemical Baselines (CGGB), and secondly towards the design and implementation of a comprehensive geochemical study of this area.

During this field campaign, the geological and geographical conditions were verified for carrying out geochemical sampling of subantarctic streams and residual soil. In particular, eight field points, ranging from the extreme north to the extreme south of the island, were visited. In all of them, the main characteristics of representative soil and deposits of sediments, including fluvial terraces, alluvial deposits, floodplains and glaciofluvial deposits, were examined.

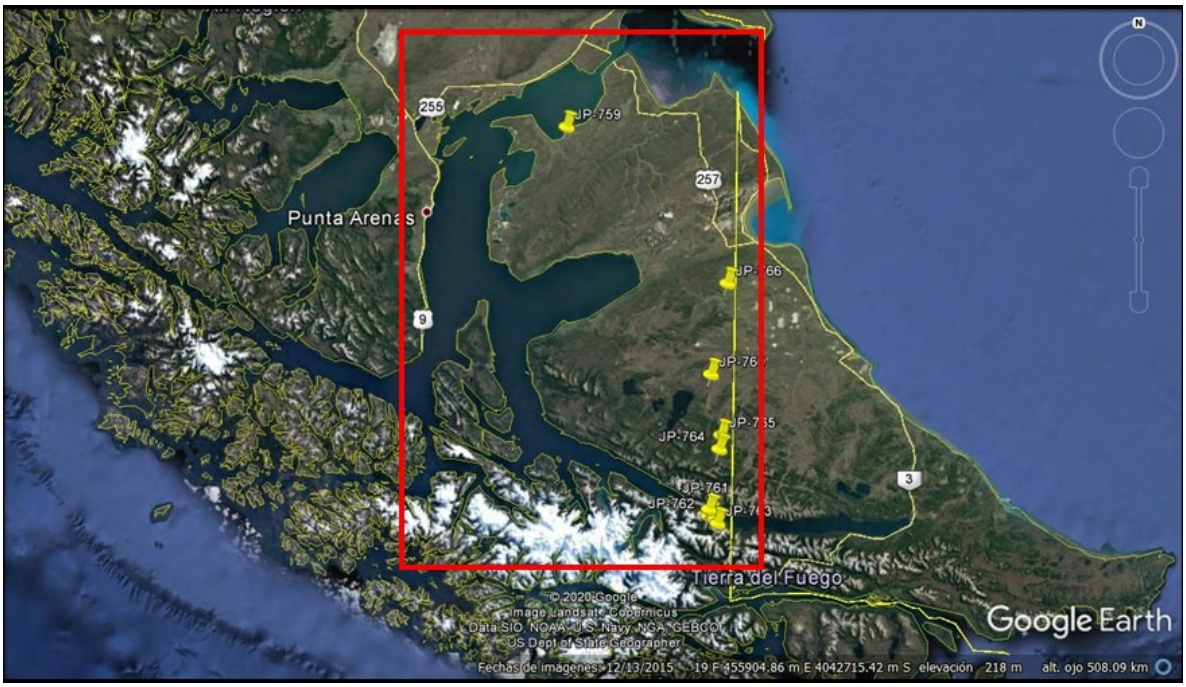


Figure A5.7. Satellite image (Google Earth) of the southern tip of South America, including Tierra del Fuego. The positions and codes of the eight field points at which geological observations and profiles of soil/sediment profiles are indicated as yellow pins. The red box of approximately 300 x 500 km corresponds to the area covered by the study. Yellow line: international border between Chile (west) and Argentina (east). The ice field of the scarcely explored Cordillera Darwin range is at the south of the study area.

A5.3.2.6. Ongoing projects during the 2020-2021 period

During the 2020-2021 period, the efforts would be also focused in the following projects:-

Integrated Geochemical-Geological-Metallogenic Atlas of northern Chile: The study area corresponds to the northern part of Chile, with a surface area of approximately 45,000 km^2 (Figures A5.8, zone E & A5.8). The goal of this project is to integrate different layers of information (sediment and soil geochemistry, bedrock geology, airborne geophysical and metallogenic data) in a single Atlas. The hypothesis is that the combination of this multiple data layers would result in new relevant geological information due to a synergy effect. The Atlas itself is intended to have on-line interactive features that would make this publically available information more attractive to technical and non-technical visitors.

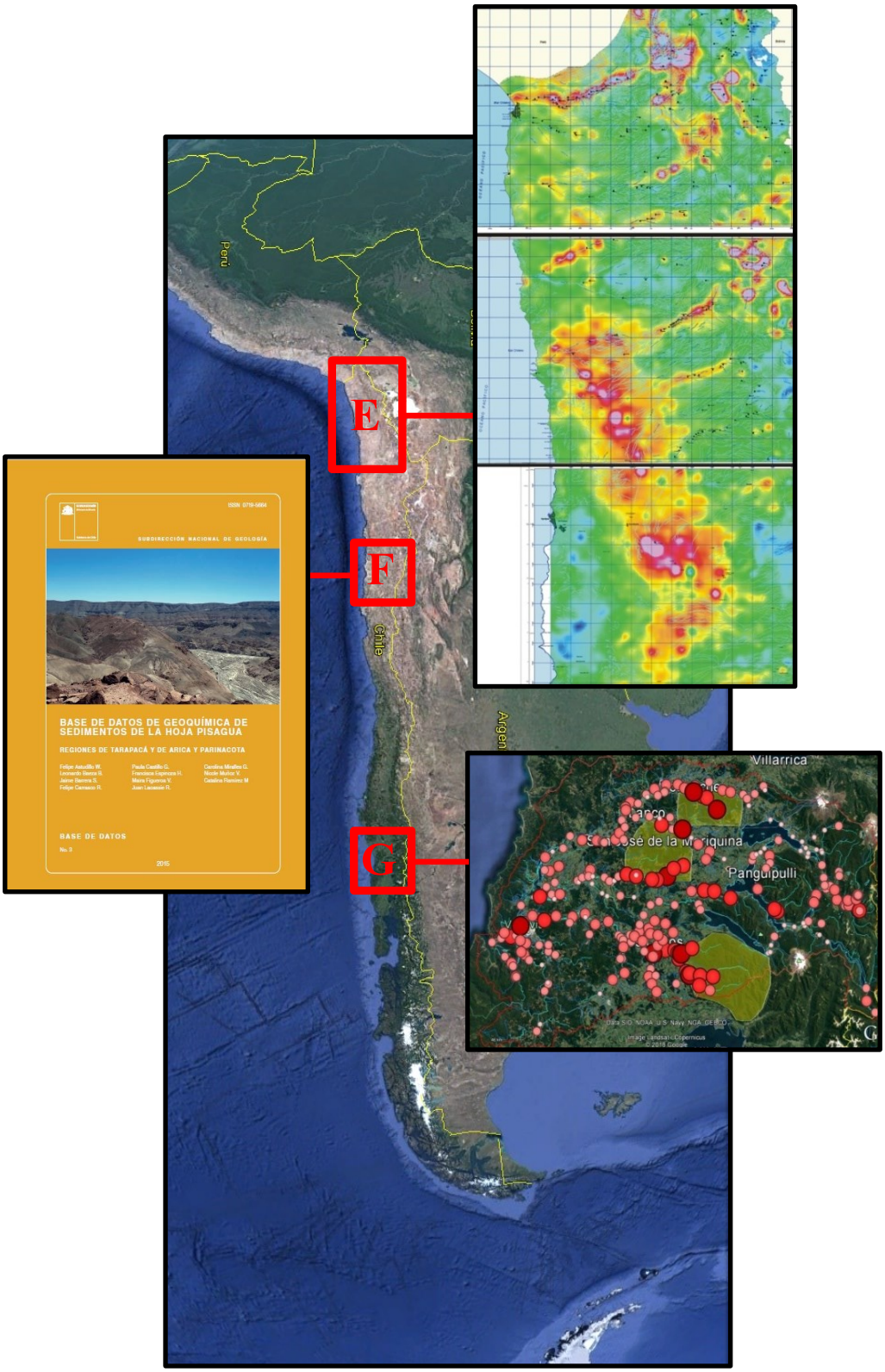


Figure A5.7. Geochemical Map of Chile (SERNAGEOMIN): Ongoing projects during the 2020-2021 period. E: Integrated Geochemical-Geological-Geophysical-Metallogenic Atlas of northern Chile. The figure shows the distribution of As concentrations in stream sediment samples of northern Chile. F: Cover page of the Geochemical database of the Copiapó and El Salvador sheets (1:250,000 scale). G: Study of the Valdivia fluvial system and Technical Report on the observed REEs anomalies in southern Chile.

Publication of the Geochemical database of the Copiapó and El Salvador sheets (1:250,000 scale): During 2020 this two large geochemical data sets (1:250,000 scale) were submitted for an internal review for publication during 2021. Each one includes the geochemical and associated field data of more than 1400 stream sediment samples, collected from this large area in northern Chile, with a combined surface area of approximately 26,000 km^2 (Figures A5.7, zone F & A5.9). This information would define the first geochemical baseline of these areas, which would be useful both for environmental and mineral exploration purposes.

Geochemical study of the Valdivia fluvial system and Technical Report on the observed REEs anomalies in southern Chile: Due to the first results of the geochemical study of the Valdivia fluvial basin, different areas with anomalous high concentrations of REEs, were defined (Figures A5.7, zone G & A5.10). During 2020 new geochemical sampling was performed in these areas using a relatively dense grid in order to better locate and characterise possible prospective targets.

Figure A5.8. Integrated Geochemical-Geological-Metallogenic Atlas of northern Chile. Collecting stream sediment from a tributary stream of the Lluta River, the northernmost fluvial basin of Chile, which comes from a hydrothermal alteration zone. Due to its high acidity, the stream water contains a high content of metals, which precipitate in the form of reddish colloids, this being a process derived from the natural conditions of this alteration zone. Photograph by Juan Pablo Lacassie.

Figure A5.9. Geochemical sampling in the Copiapó and El Salvador map sheets in northern Chile. Desolate pampas of the Atacama desert are crossed by seasonal streams in an ephemeral landscape subjected to the increasing effect of climate change. Photograph by Leonardo Baeza.

Figure A5.10. Geochemical sampling of the Valdivia fluvial system in southern Chile. The geologist Hugo Ochoa is crossing the shallow stream that drains the Pellaifa lake towards the Calafquén lake in Los Rios Region (Region of the Rivers). Photograph by Juan Pablo Lacassie.

A5.3.3. Colombia

Report by Gloria Prieto (Servicio Geológico Colombiano, Bogotá, Colombia; gprieto@sgc.gov.com; g.prietor@outlook.com)

In spite of the pandemic situation due to Covid-19 virus, during 2020, the Colombian Geological Survey advanced in geochemistry activities carrying out diverse and systematic sampling programmes. Field sampling programmes were executed until the end of March, with low-sampling density geochemical mapping as part of the Global Geochemical Baseline Project, medium sampling density for the Colombian Geochemistry Atlas, and high sampling density for mineral resources exploration, Metallogenetic Map, and for applications to minerals fingerprinting, health and environmental studies. From April to December 2020, sample analysis, data processing, map plotting, interpretation, and report production have been performed.

The geochemical group gives support to all groups that execute geochemical sampling at the Mineral Resources Division in order to apply standardised methodologies starting with sampling design, sample collection, geochemical analysis, data processing and map production.

A5.3.3.1. Low-sampling density geochemical mapping for Global Geochemical Baselines

According to the agreement between the Colombian Geological Survey (SGC) and the China Geological Survey, signed in 2016, to carry out joint diverse geochemical sampling programmes in Colombia, the Mineral Resources Division of the Colombian Geological Survey covered about 80% of the Colombian territory using a low-sampling density geochemical programme (Figure A5.11).

In 2020, the sampling programme advanced by covering three sampling stations, located in the eastern part of Colombia, the rain forest region, which is the most difficult geographical area to access. At each sampling station surface water and floodplain or overbank samples according to the catchment basin size were collected, following standardised methodologies according to the Global Geochemical Baselines Programme of UNESCO ICGG.

The water samples were analysed in the Colombian Geological Survey laboratories using standard methods. The analytical data together with the quality control parameters (QA/QC) were archived in the EXPLORA database of the Mineral Resources Division.

In the field campaign, using field protocols and formats geological data as well as environmental and social information of the working survey area are recorded (Figures A5.12 & A5.13).

According to the Agreement, signed between the SGC of Colombia and the CGS of China, the SGC sent 286 samples of floodplain and overbank sediments to the laboratories of China Geological Survey (UNESCO International Centre on Global-Scale Geochemistry) for chemical analysis.

Continuing with data analysis, Exploration Data Analysis (EDA) was carried out, univariate and bi-variate correlation analysis, cross correlation analysis, principal component analysis and element concentration maps according to catchment basins were elaborated.

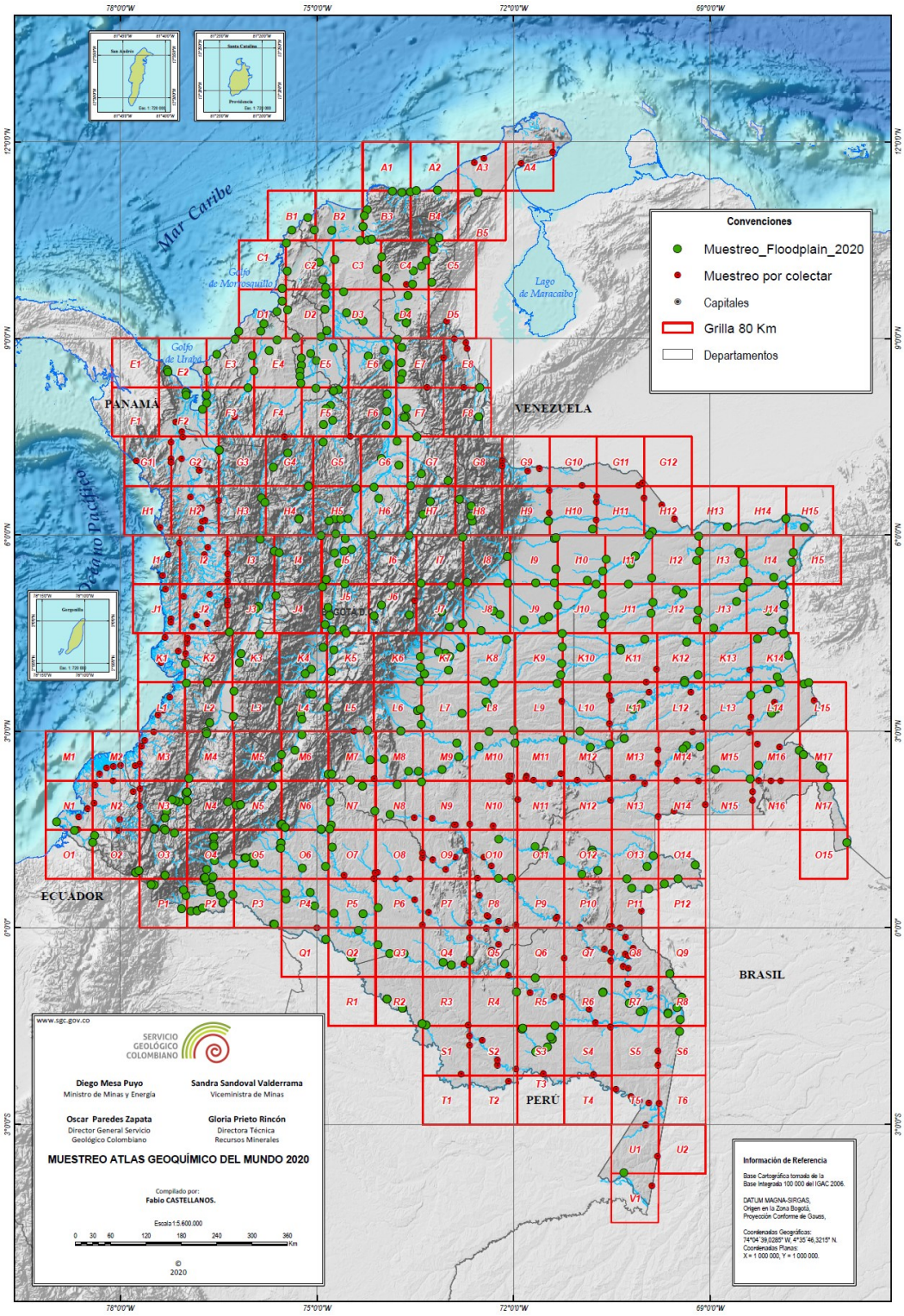


Figure A5.11. Map of Colombia, with grid cells of 80x80 km (212 cells) and random sampling sites for the Global Geochemical Baselines project.

Figure A5.12. Landscape photograph of floodplain sediment sampling site in the Amazonas Region (Amazon River), Nariño Port, Colombia (see Figure A5.13).

(a)

(b)

Figure A5.13. (a) Close-up of floodplain sediment profile down to 160 cm depth. Note the different floodplain sediment layers (see Figure 2); (b) Bagged top floodplain sediment sample.

A5.3.3.2. Geochemical Atlas of Colombia

Regarding medium-density sampling (grid of 5x5 km) for the Colombian Geochemical Atlas, 300 samples (stream sediment, water, soil) were sent to laboratories for chemical analysis.

Until 2020, 40% of the Colombian territory was covered with medium sampling density (Figure A5.14).

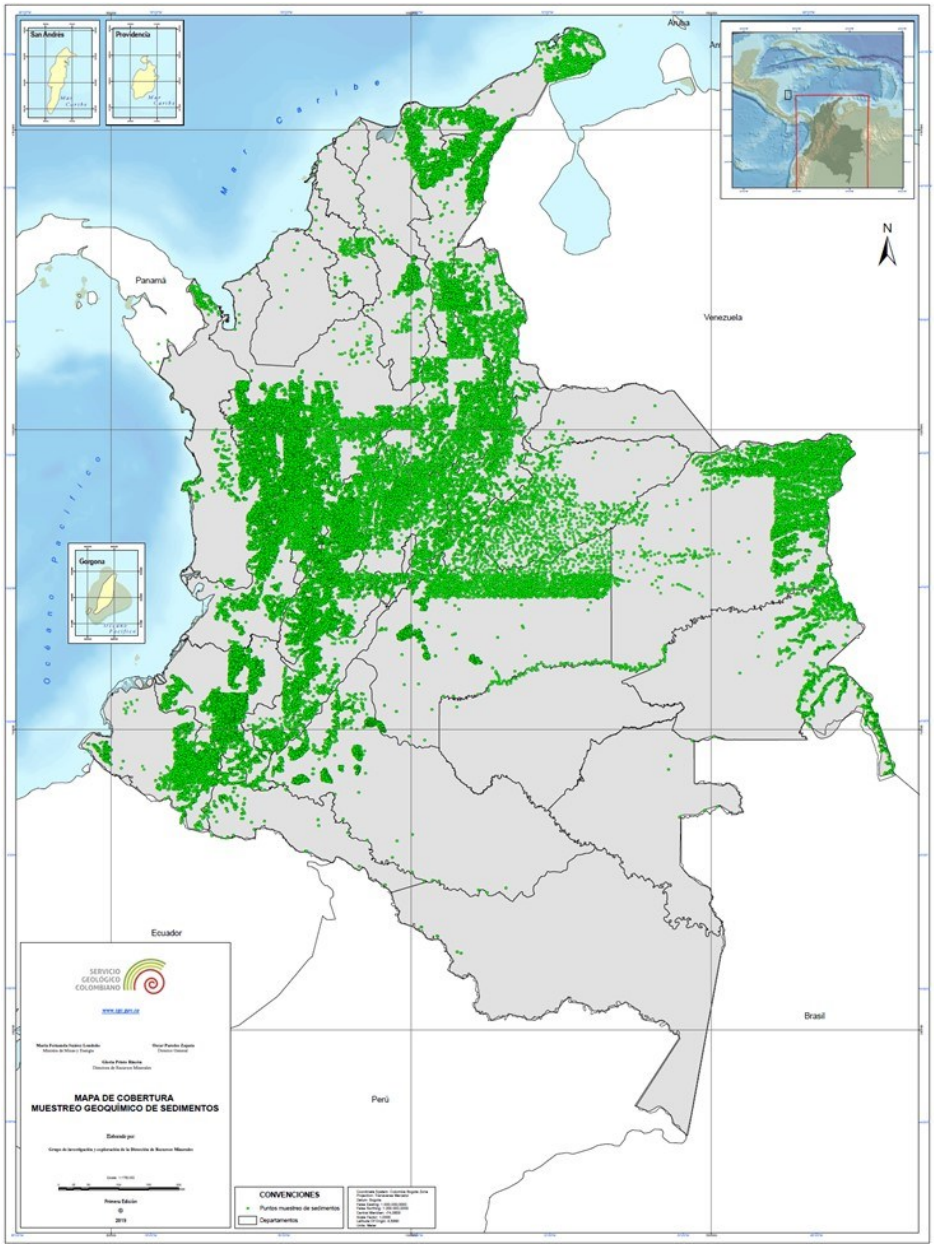


Figure A5.14. Map showing the coverage with stream sediments at low and high sampling density, according to geochemical data use (1 sample/25 km^2, 1 sample/16 km^2, 1 sample/9 km^2 and 1 sample/1 km^2). Note: The different sampling densities are indicated by the closeness of the green dots.

A5.3.3.3. Colombian Geochemical Atlas, 2020 version

During 2020 and taking into account the fieldwork restrictions due to the Covid-19 pandemic in Colombia, the geochemical group dedicated efforts to produce the new version of the Colombian Geochemical Atlas.

The Colombian Geochemical Atlas 2020 version has a presentation scale of 1:6,000,000 and it includes data of 85,387 sediment samples for 57 chemical elements reaching a total of 228

maps. Each element is represented by four (4) maps: (a) chemical concentration distribution (Figure A5.15); (b) sample distribution; (c) chemical analysis technique, and (d) chemical analysis decomposition.

Additionally, each distribution map contains basic statistics, and the atlas includes for each element a description with general information (origin, minerals, chemical characteristics, health concerns and environment behaviour), and a description about its geochemical distribution in Colombia.

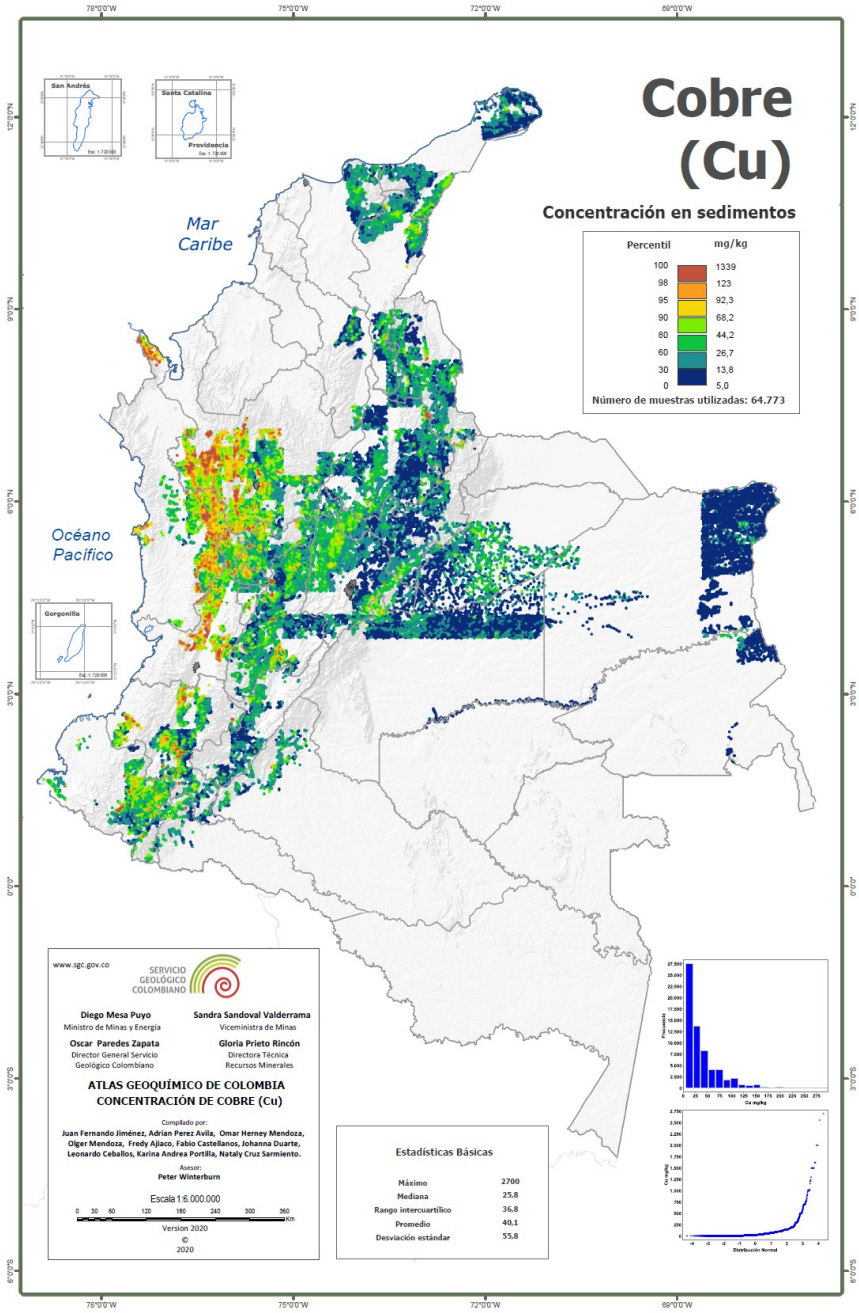


Figure A5.15. Distribution map of Cu (mg/kg) in stream sediment samples, Colombian Geochemical Atlas 2020.

A5.3.3.4. Geochemical sampling to evaluate mineral resource potential

To evaluate mineral resource potential in metallogenic districts, the Colombian Geological Survey carried out a geochemical high-sampling density programme in ten districts with a potential for Cu–Au and polymetallic minerals. Following standard methodologies, samples of

stream sediment, soil, rock and water were collected in three districts. In addition, altered minerals, mineralised rocks, and panned concentrates were sampled. The samples after preparations were sent to the laboratories of the SGC and to commercial laboratories for chemical analysis. Field and analytical information was 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 region and by catchment basin.

Considering future fieldwork, the group evaluated geochemical information (QA/QC) for 9 new metallogenic districts, and also updated sampling design, sampling protocols and data processing to identify geochemical anomalies (Figure A5.16).

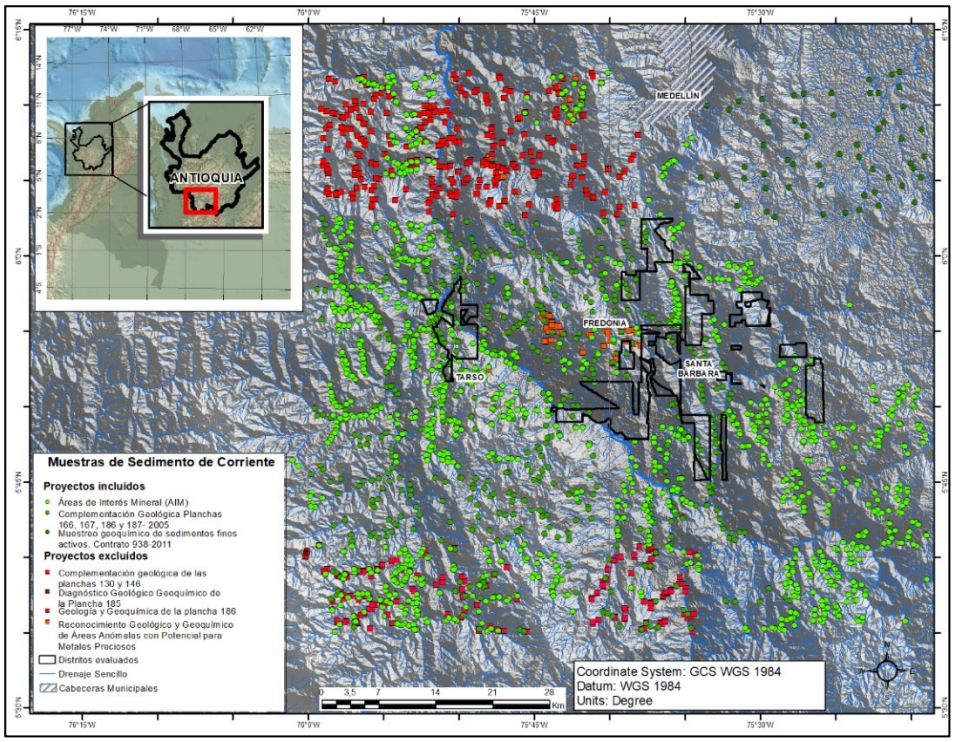


Figure A5.16. Stream sediment sampling sites in Fredonia – Antioquia district.

A5.3.3.5. Geochemical Sampling for Environmental Geochemistry and Geomedicine

Related to geochemical sampling applied to environment and health studies, the group continued its systematic sampling programme in coal basins in order to establish Hg baselines of Colombian coal (Figure A5.17). Due to the fieldwork restrictions for the Covid-19 pandemic situation, the main activity was chemical analysis of collected samples, data processing, map plotting, interpretation, and report writing.

A5.3.3.6. Mineral fingerprinting

The geochemistry programme of the Colombian Geological Survey, Mineral Resources Division, continues by advancing the project to identify mineral fingerprinting. The geochemistry group performed analytical work in collaboration with the laboratories in South Africa and Australia. Finally, data processing, interpretation and identification of geochemical associations were performed in order to identify Au fingerprinting (Figure A5.18).

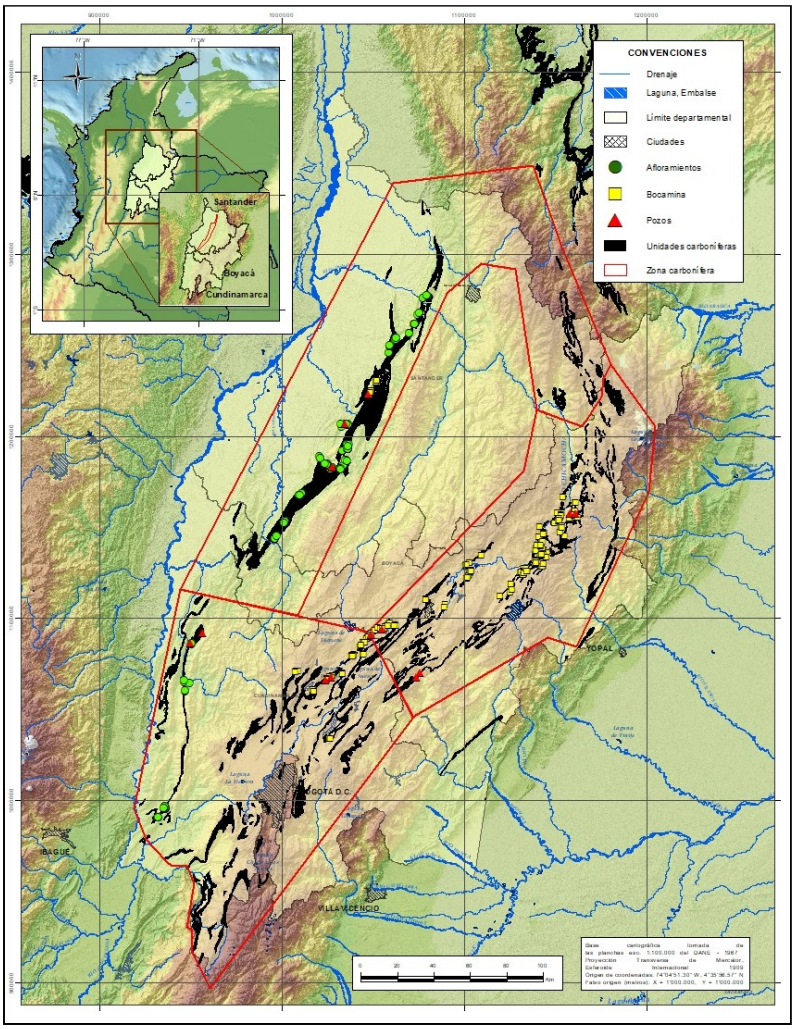


Figure A5.17. Researched coal basins of Colombia to establish Hg baselines in coal.

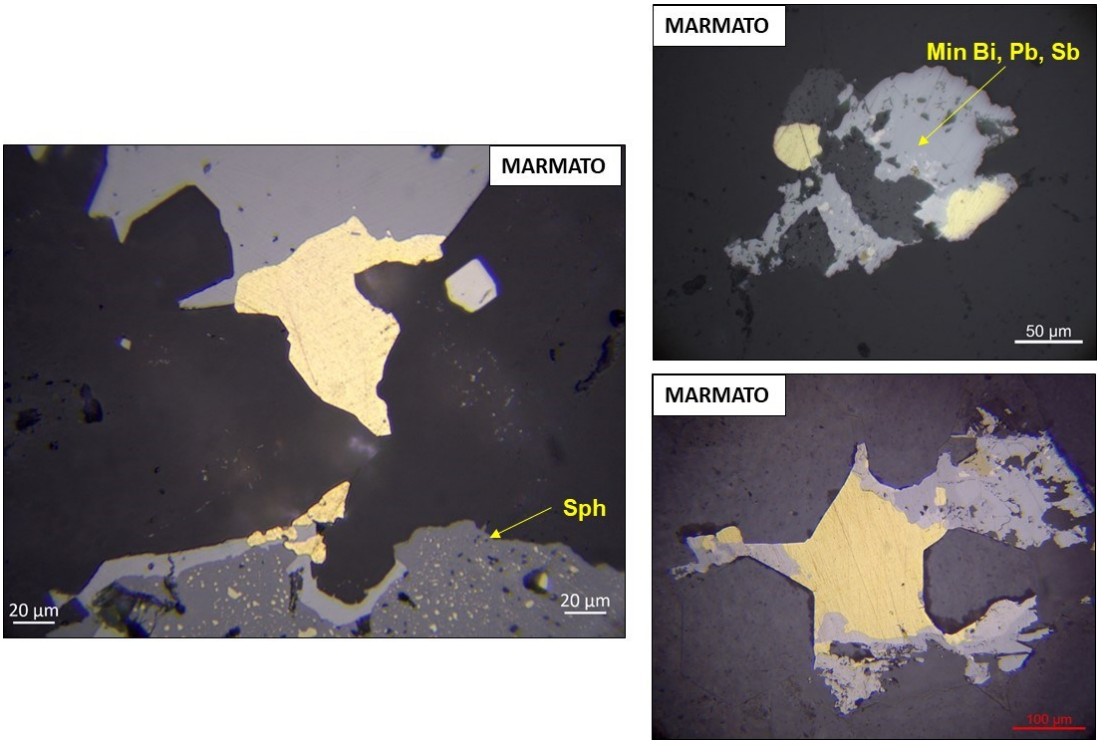


Figure A5.18. Petrography of Au-bearing minerals of the Marmato mining district.

A5.4. ASIA

A5.4.1. Armenia

Report by Gevorg Tepanosyan, Olga Belyaeva, Lilit Sahakyan (Centre for Ecological Noosphere Studies NAS RA; gevorg.tepanosyan@cens.am; olga.belyaeva@cens.am; lilit.sahakyan@cens.am)

A5.4.1.1. Environmental geochemical and radioecological surveys in Armenia

The main activities of the Environmental Geochemistry department at the Centre for Ecological-Noosphere Studies (CENS) of the National Academy of Sciences of the Republic of Armenia (RA) during 2020 has been the continuation of the soil geochemical survey of Armenian regions.

In 2020, within the project funded by the Science Committee of the MES of RA entitled '*Development of Geochemical Maps to Ensure Sustainable Agricultural Development and Food Safety – GeoMAS*' (1-12/TB, 2019-2023) the results of the Armavir region soil survey were finalised (Tepanosyan *et al.*, 2021). A soil survey (0-20 cm) of another part of Armenia - Ararat region (2090 km^2) was performed. In total, 84 samples (1 sample/25 km^2) were collected and analysed by X-ray fluorescence spectrometry and gross alpha/beta counting system. The results showed that the contents and spatial distribution of the studied elements (Cr, V, Ti, As, Zn, Cu, Co, Fe, Mn, Ba, Pb, Ca, K, and Mo) are affected both by the peculiarities of the region's geology and known sources of contamination. Moreover, the application of compositional data analysis allowed the identification of three different clusters of samples (natural, anthropogenic and mixed), which appeared to have also distinct spatial separation. Among the studied elements, Cr and As display excesses in relation to the nationally stated Maximum Acceptable Concentration values throughout the studied territory. The Gold plant was identified to be the potential source of As potentially hazardous concentrations. Maxima values of gross alpha and beta activities were observed in the area, which coincide with the uranium-rich Vedi-Vayk mineral field. The absorbed dose rate in air increases with altitude, and correlates significantly well with the gross beta activity in soil.

Within CENS core scientific topic entitled 'Environmental Geo-Ecological Studies' (State Budgetary Fund 2020), the regional soil survey of Gegharkunik region (5,349 km^2) of Armenia was performed (0-20 cm), and 200 soil samples (1 sample/25 km^2) were collected, which are now in the process of pretreatment and analysis. Moreover, within the frame of the same scientific topic the Radioecology Department completed environmental radioactivity studies of the biggest cities of Armenia using archived soil samples of multipurpose geochemical surveys implemented in the period of 2012-2017. Details on the urban soil radioactivity surveys results can be found in Belyaeva *et al.* (2020, 2021).

A5.4.1.2. Published articles, papers, atlases and books

Belyaeva, O.A., Pyuskyulyan, K.I., Movsisyan, N.E., Sahakyan, L.V. & Saghatelyan, A.K., 2020. Radioecological studies in Armenia: a review. Natural Sciences: Electronic Journal of National Academy of Sciences of Republic of Armenia, 34(1), 34–40.

Belyaeva, O., Movsisyan, N., Pyuskyulyan, K., Sahakyan, L., Tepanosyan, G. & Saghatelyan, A., 2021. Yerevan soil radioactivity: Radiological and geochemical assessment. Chemosphere, 265, 129173; https://doi.org/10.1016/j.chemosphere.2020.129173.

Tepanosyan, G., Sahakyan, L., Maghakyan, N. & Saghatelyan, A., 2021. Identification of spatial patterns, geochemical associations and assessment of origin-specific health risk of potentially toxic elements in soils of Armavir region, Armenia. Chemosphere, 262, 128365; https://doi.org/10.1016/j.chemosphere.2020.128365.

A5.4.2. China

Report by Xueqiu Wang Xueqiu (Chief Scientist, Institute of Geophysical and Geochemical Exploration & Executive Director, UNESCO International Centre on Global-Scale Geochemistry (ICGG), Langfang, P.R. China; geochemistry@sina.com)

A5.4.2.1. Summary

1. Scientific Research Activities

- In 2020, the ICGG has cooperated with Colombia, Peru and Turkey in global geochemical baselines mapping, and covered an area of 1.8 million km^2.
- A total of 1589 observation locations of China Geochemical Observatory Network for monitoring the environmental changes was established in 2020.

2. Training, Education and Visiting Scholar

- 1 visiting scholar in ICGG for short-term research work.
- 5 Ph.D. students are doing their doctorate research work under Prof. Xueqiu Wang, and 3 students obtained their Ph.D. degree in 2020.

3. Data Sharing and Science Popularisation

- Updating the global geochemical data with 40 elements and maps with 27 elements through platform 'Chemical Earth'.
- Geochemical data sharing with Laos, Colombia and Cambodia.
- Publication of science popularisation video of Geochemical Mapping and Necessities of Life in China by the largest internet media 'Xinhua' (http://www.xinhuanet.com/expo/2018-12/11/c_1123837059.htm?ADUIN=20688660&ADSESSION=1544748632&ADTAG=CLIENT.QQ.5599_.0&ADPUBNO=26866).

A5.4.2.2. Scientific research activities of the ICGG in 2020

1.1. Global Geochemical Baselines supported by China

The ICGG in cooperation with Laos, Mongolia, Colombia, Peru, Iran, Russia, Eritrea, Tanzania, Mexico, Turkey, Colombia, Guinea *etc.* has conducted Global Geochemical Baselines by collecting in total 3694 catchment sediment[2] samples, covering an area of 7.8 million km^2 from 2016 to 2020. In 2020, field sampling of 492 locations (984 samples) throughout Turkey, and

[2] Comment 1 by Alecos Demetriades, Commission's Sampling Committee Chair:- It is here necessary to explain the difference between the term '*catchment sediment*', which is wrongly mentioned in the report from China, and '*floodplain sediment*', which is the term that should have been used in this report. The term is not '*catchment sediment*' but '*catchment outlet sediment*', which was first used in Australia to describe 'overbank or floodplain sediments' with an aeolian contribution. According to Caritat and Cooper (2011, p.5) "*The term 'catchment outlet sediment' is deliberately chosen because it is more general than 'floodplain sediment' to allow for those cases where aeolian influence is important in the regolith formation process*". Mann *et al.* (2012, p.277-278) provide a more extensive explanation "*The ultra-low density continental geochemical survey targeted transported regolith samples collected on the floodplains of large catchments, as much as possible. Because in many places the influence of aeolian material cannot be avoided in Australia, this medium was more generally termed 'catchment outlet sediment' and was collected at the lower point of large catchments, be it on the catchment boundary or somewhere more central for internally draining catchments*." The terms '*overbank sediment*' and '*floodplain sediment*', collected from second and third order streams are used in the 'Blue Book' by Darnley *et al.* (1995, p.30), and the FOREGS Geochemical Mapping Field Manual (Salminen, Tarvainen *et al.*, 1998, p.25): *Overbank or floodplain sediments are fine-grained sediments deposited in low-energy environments by receding floodwaters, and they should, therefore, be devoid of pebbles, which indicate medium energy environments* (Ottesen *et al.*, 1989, p.262). Therefore, one has to be extremely careful when using terms.

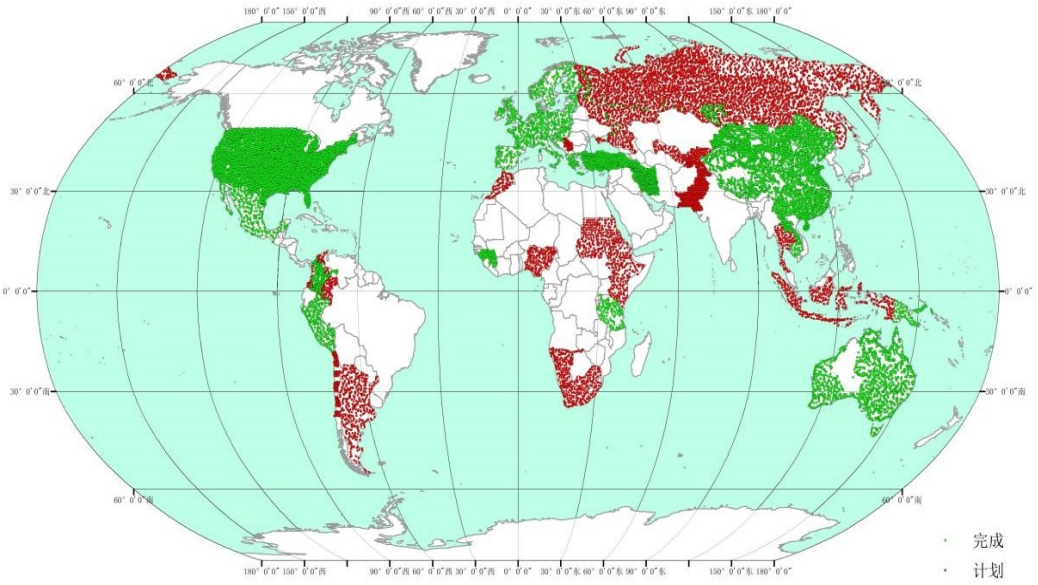


Figure A5.19. Progress of Global Geochemical Baselines[3] project with sample locations (green dot[4]: sampling completed as of 2020; red dot: planned sampling).

laboratory chemical analysis of 232 samples from Colombia and 200 samples from Peru were analysed[5].

(1) China-Colombia cooperation

The Geological Survey of Colombia has completed the sampling of 340 global geochemical baselines samples throughout its territory by collecting a total of 680 catchment sediment samples, with a sampling density of 16 sites/160x160 km from 2018 to 2019. The samples were shipped to China for laboratory analysis. The ICGG laboratory has completed the analysis of 232 samples by determining 76 elements in 2020.

(2) China-Peru Cooperation

The China Geological Survey and Institute of Geology, Mining and Metallurgy of the Ministry of Energy and Mineral Resources of Peru signed in 2009 an MoU for cooperation in the field of geosciences between the two countries. The Institute of Geology, Mining and Metallurgy of the Ministry of Energy and Mineral Resources of Peru has completed the sampling of 100 global geochemical baselines sample locations by collecting 200 samples at a density of 1 site/80×80 km in 2018 in the western mountainous area of Peru after the field training given by Prof. Wang Xueqiu. In 2019, the Institute of Geophysical and Geochemical Exploration of China (IGGE) and Institute of Geology, Mining and Metallurgy of the Ministry of Energy and Mineral Resources of Peru have jointly completed the sampling of 40 global geochemical baselines

[3] Comment 2 by Alecos Demetriades, Commission's Sampling Committee Chair:- The progress of the Global Geochemical Baselines project as shown on the map is not according to the specifications of the 'Blue Book' by Darnley *et al.* (1995), because IGGE and the UNESCO ICGG are only collecting samples of floodplain sediment from large third or higher order streams.

[4] Comment 3:- The sampling coverage according to sample type, as presented on the map, is wrong. In the conterminous United States of America (Smith *et al.*, 2014) and Mexico soil samples were collected, and not floodplain sediment samples. Hence, these countries should not be presented on the same map because it gives false information.

[5] Comment 4:- Analysis of the sample batches as collected is undoubtedly a procedure that is strongly not recommended, as the objective is to produce a harmonised and comparable database. The experience in Europe from the carrying out of three pan-European projects is that all collected samples must be analysed in the same laboratory for the same suite of elements and parameters, and in the shorter possible time period, because this is the only way to ensure that the generated data are comparable. Hence, as presented the generated data are of questionable value.

sample locations by collecting 80 samples in the rainforest area of north-eastern Peru. In 2020, the analysis of 200 samples has been completed in the China IGGE laboratory.

(3) China-Turkey cooperation

The China Geological Survey (CGS) and General Directorate of Mineral Research and Exploration, the Ministry of Energy and Natural Resources of the Republic of Turkey signed an MoU in 2015. In 2018, the CGS and the TMA signed the 'Turkey Global Geochemical Baselines' cooperation agreement to complete the Turkey global-scale geochemical baselines research project from 2018 to 2020. The nominal sampling density is one site per 40x40 km, and the plan is to collect samples from 500 locations throughtout Turkey. Two samples were collected at each location, surface (0-25 cm) and deep (100-150 cm) samples, for a total of about 1,000 samples. A total of 76 elements will be determined in China laboratories. The two parties formed a joint field sampling team by collecting 214 samples at 107 sites in 2019, and the samples shipped to China for analysis. The Turkish side has collected in 2020 samples at 375 sites. In total, 1002 samples were collected from 482 locations covering the whole territorry of Turkey.

1.2. China Geochemical Observatory Network

In 2020, a total of 1589 observation locations of China Geochemical Observatory Network for monitoring the environmental changes was established at 3682 catchment sample locations, thus completing the first round of the China Geochemical Baselines project (2008-2012).

2. Training, Education and Visiting Scholars

2.1. Training course

On November 5th and 6th of 2019, Drs. Zhang Bimin, Zhou Jian, Liu Donsheng and Li Ruihong of ICGG went to Laos for project implementation, during which, the ICGG staff carried out a detailed training on geochemical sampling technologies and safety issues. Over 10 staff members from the Department of Geology and Minerals of the Ministry of Energy and Deposits of Laos participated in the training, which covered the following themes: (1) field safety; (2) field preparation; (3) field location and recording; (4) field sampling methods; (5) daily fieldwork completion process, including self-inspection, inter-inspection and data sorting; (6) field quality inspection; (7) sample storage and processing, and (8) overall fieldwork completion.

2.2. Ph.D. Student Education

In 2020, 5 Ph.D. students and 1 master student are doing their Ph.D. and M.Sc. degrees under the supervision of Prof. Xueqiu Wang and 3 students obtained their Ph.D. degrees.

2.3. Visiting scholars

Walid Samir Hindy Salama, Senior Geochemist, National Resource Research Centre, Commonwealth Scientific and Industrial Research Organisation (CSIRO) was invited as a visiting scolar at the ICGG from the 25th of November until the 18th December of 2019.

3. Data sharing and Science Popularisation

3.1. Data sharing

(1) From 2018 to 2020, the ICGG has further provided global geochemical data with 40 elements and maps with 27 elements through the 'Chemical Earth' platform (www.globalgeochemistry.com).

(2) Geochemical data sharing with Laos, Colombia and Cambodia.

3.2. Science Popularisation

Publication of science popularisation video of Geochemical Mapping and Necessities of Life in China by the largest internet media 'Xinhua (http://www.xinhuanet.com/expo/2018-12/11/c_1123837059.htm?ADUIN=20688660&ADSESSION=1544748632&ADTAG=CLIENT.QQ.5599.0&ADPUBNO=26866).

References cited in the footnotes by Commission's Sampling Committee Chair

Caritat, P. de, Cooper, M., 2011. *National Geochemical Survey of Australia: Data Quality Assessment*. Geoscience Australia, Record 2011/21, GeoCat 71971, Australian Government, Canberra, Vol. 1, 1-268; https://d28rz98at9flks.cloudfront.net/71971/Rec2011_021_Vol1.pdf.

Darnley, A.G., Björklund, A., Bølviken, B., Gustavsson, N., Koval, P.V., Plant, J.A., Steenfelt, A., Tauchid, M., Xuejing, Xie., Garrett, R.G. & Hall, G.E.M., 1995. *A Global Geochemical Database for Environmental and Resource Management. Recommendations for International Geochemical Mapping – Final Report of IGCP Project 259*. Earth Science Report 19. UNESCO Publishing, Paris, 122 pp.; https://globalgeochemicalbaselines.eu.176-31-41-129.hs-servers.gr/datafiles/file/Blue_Book_GGD_IGCP259.pdf.

Mann, A., Caritat, P. de & Prince, P., 2012. *Bioavailability of nutrients in Australia from Mobile Metal Ion® analysis of catchment outlet sediment samples: continental-scale patterns and processes*. Geochemistry: Exploration, Environment, Analysis, 12(4), 277-292; https://doi.org/10.1144/geochem2011-090.

Ottesen, R.T., Bogen, J., Bølviken, B. & Volden, T., 1989. *Overbank sediment: a representative sample medium for regional geochemical mapping*. In: S.E. Jenness (Editor), Geochemical Exploration 1987. Journal Geochemical Exploration, 32(1-3), 257-277; https://doi.org/10.1016/0375-6742(89)90061-7.

Salminen, R., Tarvainen, T., Demetriades, A., Duris, M., Fordyce, F.M., Gregorauskiene, V., Kahelin, H., Kivisilla, J., Klaver, G., Klein, P., Larson, J.O., Lis, J., Locutura, J., Marsina, K., Mjartanova, H., Mouvet, C., O'Connor, P., Odor, L., Ottonello, G., Paukola, T., Plant, J.A., Reimann, C., Schermann, O., Siewers, U., Steenfelt, A., Van Der Sluys, J. & Williams, L., 1998. *FOREGS Geochemical Mapping Field Manual*. Geological Survey of Finland, Espoo, Guide 47, 36 pp.; http://tupa.gtk.fi/julkaisu/opas/op_047.pdf.

Smith, D.B., Cannon W.F., Woodruff, L.G., Solano, F., Ellefsen, K.J., 2014. *Geochemical and mineralogical maps for soils of the conterminous United States*. U.S. Geological Survey Open-File Report 2014-1082, 386 pp.; http://pubs.usgs.gov/of/2014/1082/pdf/ofr2014-1082.pdf; http://dx.doi.org/10.3133/ofr20141082.

A5.4.3. India

Report by Pradip K. Govil (National Geophysical Research Institute, Hyderabad, India)

Due to Covid-19, no applied geochemical activities are reported for 2020, except publication of a paper on the Geochemical Baseline atlas of India:

Govil, P.K., Keshav Krishna, A. & Dimri, V.P., 2020. *Global Geochemical Baseline Mapping in India for Environmental Management Using Topsoil*. Journal of the Geological Society of India volume 95, 9–16; https://doi.org/10.1007/s12594-020-1381-8.

A5.4.4. Japan

Report by Atsuyuki Ohta (Geological Survey of Japan, AIST, Tsukuba; a.ohta@aist.go.jp).

The Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology, developed a comprehensive geochemical map both for the terrestrial and coastal sea area (https://gbank.gsj.jp/geochemmap/). The aims of this project are:

1) to estimate the natural background of 53 elements including potential hazardous elements (PHEs) such as As, Cd, and Hg for environmental assessment and mineral exploration; and
2) to elucidate particle transfer processes from land to sea and within the sea.

The regional geochemical mapping project avoids anthropogenic contamination because the project is intended to estimate a natural geochemical baseline. As a next stage, a higher density geochemical mapping project in an urban region has been preceded from 2010 to elucidate contamination processes of elements released through anthropogenic activity to stream sediments. In 2015, higher sampling density geochemical maps of 53 elements for the Kanto region, which includes the nation's capital Tokyo, were published (https://gbank.gsj.jp/geochemmap/kanto/KantoHome.htm).

Subsequently, a higher sampling density geochemical mapping project was carried out in Tokai region around Nagoya city. Tokai region is one of the major metropolitan and industrial areas in Japan. In total, 1,058 stream sediment samples were collected from river beds in the Tokai region. The average sampling density is 1 sample/9 km^2, which is about ten times more than the national mapping density at 1 sample/100 km^2. The samples were air-dried, and subsequently sieved with a 83-mesh (180 μm) screen. Magnetic minerals were removed using a magnet to minimise the effect of their excess accumulation. The samples were digested in a hot HF-HNO_3-$HClO_4$ acid mixed solution. The concentrations of 41 elements were determined using ICP–AES for Na, Mg, Al, P, K, Ca, Ti, Mn, Fe, V, Sr, and Ba; ICP–MS for Li, Be, Sc, Cr, Co, Ni, Cu, Zn, Ga, As, Rb, Y, Zr, Nb, Mo, Cd, Sn, Sb, Cs, La, Ce, Hf, Ta, Tl, Pb, Bi, Th, and U, and AAS for Hg.

The terrestrial geochemical maps of the aforementioned elements were combined with the existing marine geochemical maps (Figure A5.20). The high Cr concentrations in the terrestrial area are attributed to the ultramafic rocks occurring in the region. The high Cr concentrations continue from land to the adjacent coastal sea. The spatial distribution of Cr in land and sea show the transfer process of terrestrial materials supplied through the riverine system, the initial depositional process near the shore, and dispersive process offshore. Areas of high concentrations with respect to Ni, Cu, Zn, As, Mo, Cd, Sn, Sb, Hg, and Pb are found around high-densely populated areas and in the adjacent inner bay areas. It is possible to identify the detailed distribution of these elements, and to visualise the transportation process of the PHEs from land to sea through the drainage network. We are preparing to publish The second set of

higher sampling density geochemical maps of Tokai region are being prepared for publication and will be stored in the national Geochemical Database.

Apart from the normal geochemical distribution maps, three dimensional (3D) geochemical maps on a trial basis are plotted for Cu, Cr, Hg, and Pb (https://gbank.gsj.jp/geochemmap/setumei/3Dmap.html). The spatial distribution patterns of Cu, Cr, Hg, and Pb concentrations in stream and marine sediments are superimposed on a 3D topographical map of Japan (Figure A5.21). The length and colour of pins on this map show the high or low concentrations of elements at the sampling sites. Using the 3D maps, the influence of geomorphological changes on the spatial distribution of elements can be elucidated more easily, and the transfer process of elements in the terrestrial area and from the terrestrial to the adjacent coastal sea area can be more accurately identified.

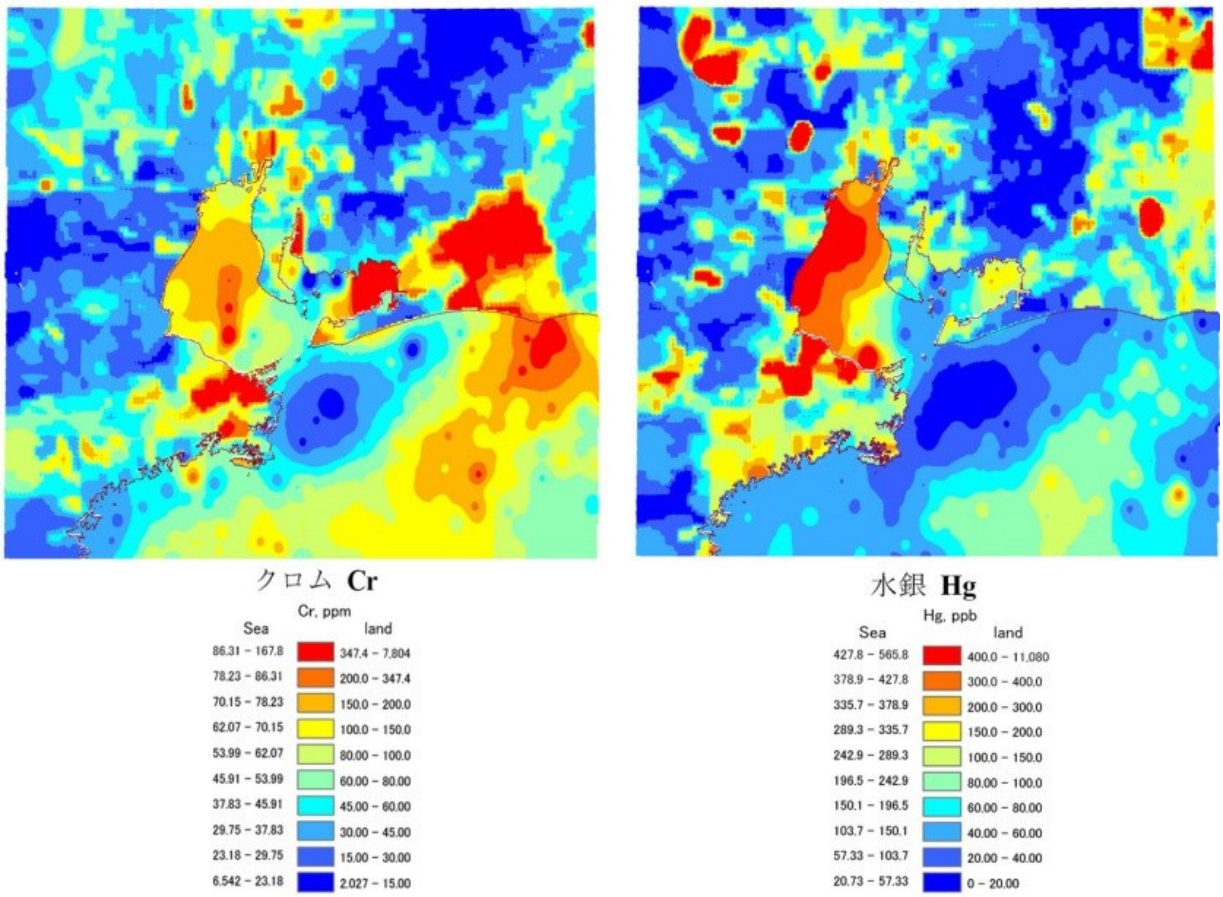


Figure A5.20. Higher density geochemical maps of Cr and Hg in Tokai region.

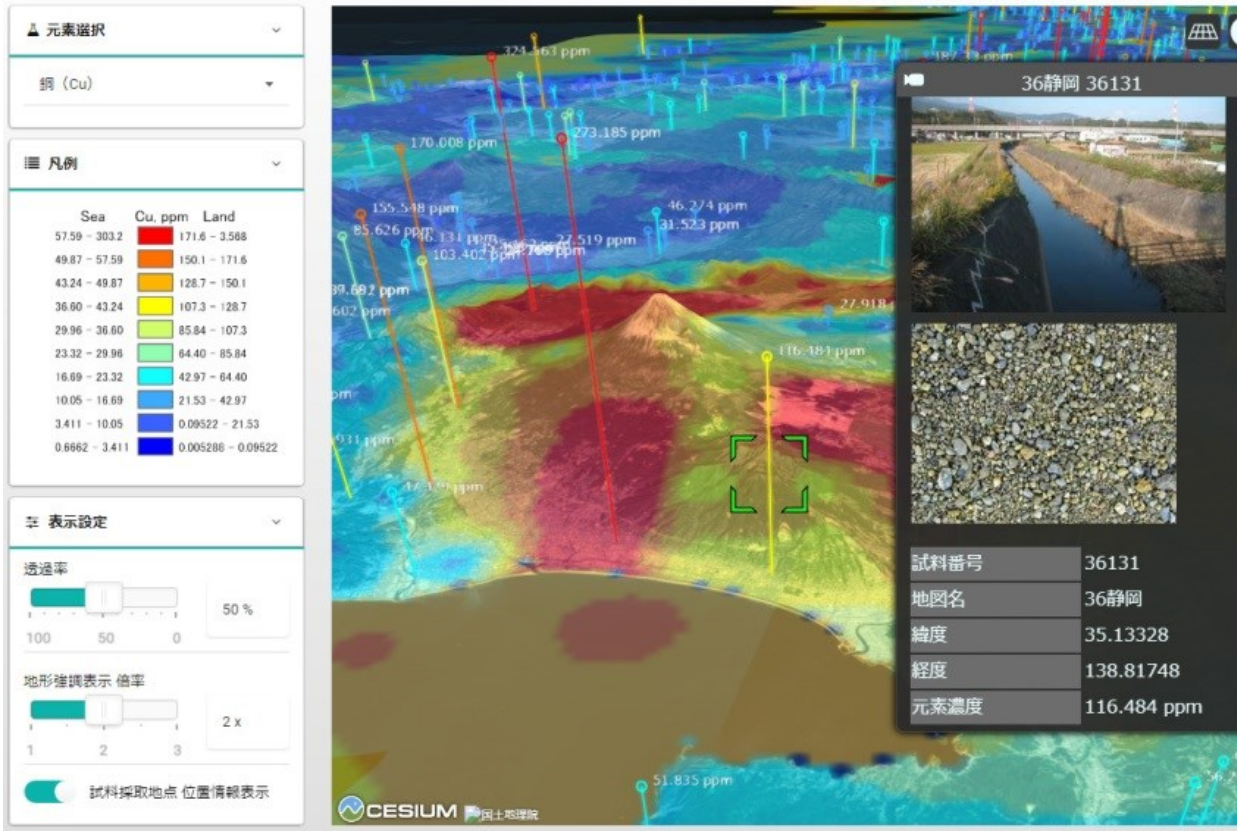


Figure 5.21. A 3D geochemical map of Cu around Mount Fuji.

A5.5. AUSTRALASIA

A5.5.1. Australia

Report by Patrice de Caritat (Geoscience Australia; Patrice.DeCaritat@ga.gov.au)

In 2020, national-scale work in Australia consisted mainly in testing and planning data acquisition around the existing sample archive. Pilot projects were run for both Sr isotopes and heavy mineral characterisation (Figure A5.22). It is hoped that some funding in following years can support some of these developments. A complete national data set of regolith Pb isotopes was collected as part of a Ph.D. project at the University of Melbourne by Ph.D. candidate Candan Desem over the last two years. The Ph.D. will be completed in late 2021, and it is hoped the national Pb isotope map and data set will be released publicly either in late 2021 or in 2022.

A5.5.1.1. Oral and poster presentations

Desem, C.U., Maas, R., Woodhead, J., Carr, G. & Caritat, P. de, 2020. *Towards a Pb isotope regolith map of the Australian continent: a Northern Territory perspective*. In: Czarnota, K., Roach, I., Abbott, S., Haynes, M., Kositcin, N., Ray, A. & Slatter, E. (eds.) Exploring for the Future: Extended Abstracts: 1-4. Geoscience Australia, Canberra; https://doi.org/10.11636/134130; available at: https://ecat.ga.gov.au/geonetwork/srv/eng/catalog.search#/metadata/134130.

A5.5.1.2. Articles, papers, atlases and books

Caritat, P. de, Mcinnes, B.I.A. & Rowins, S.M., 2020. *Towards a heavy mineral map of the Australian continent: A feasibility study*. Geoscience Australia Record, 2020/031, 31 pp.;

https://doi.org/10.11636/Record.2020.031; available at: http://pid.geoscience.gov.au/dataset/ga/144399.

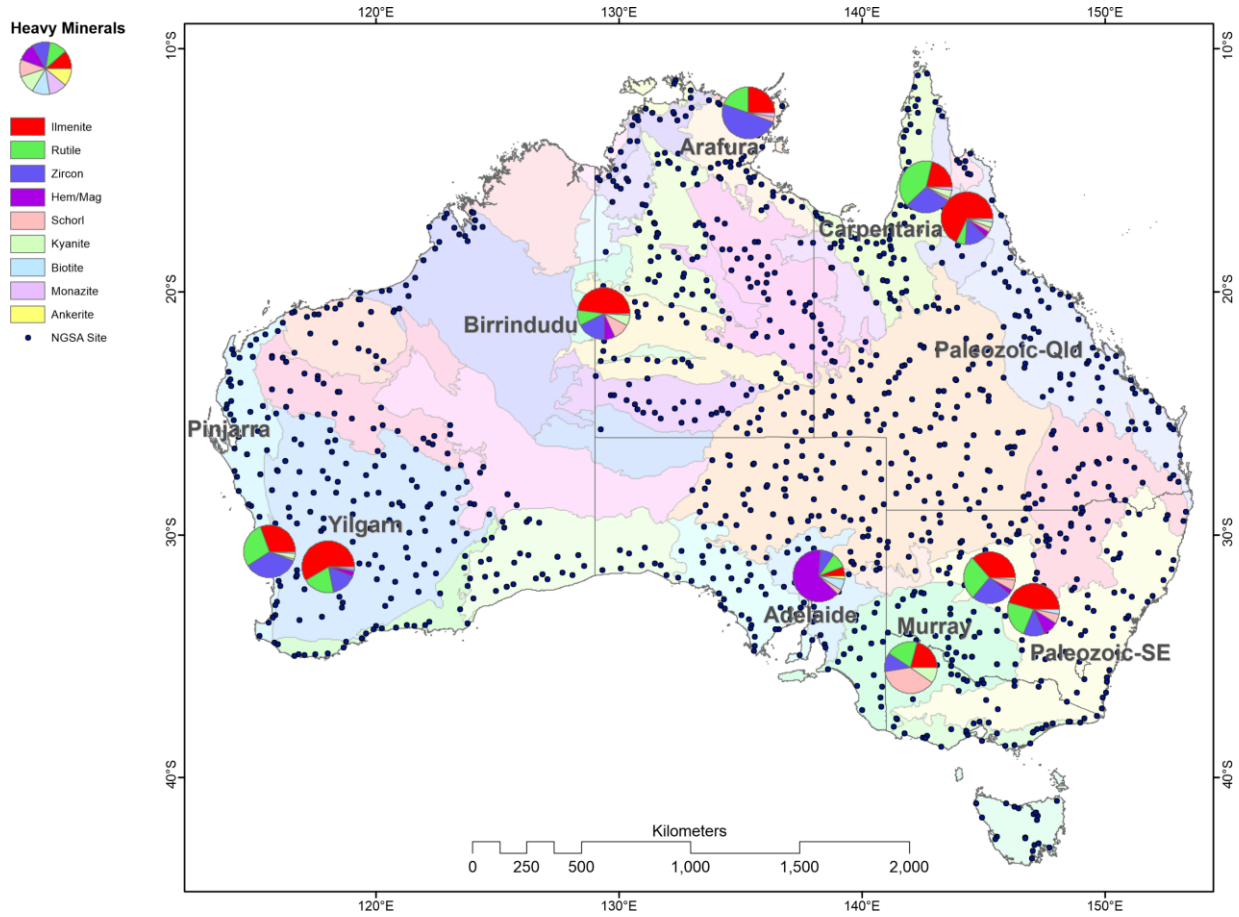


Figure A5.22. Distribution map of the nine most abundant heavy minerals in the heavy mineral concentrates of the 10 National Geochemical Survey of Australia (NGSA) samples used in the present pilot project, overlain on Australia's geological regions. Source: Caritat et al., 2020, GA Record 2020/031.

A5.5.2. New Zealand

Report by Adam Martin (GNS Science; a.martin@gns.cri.nz)

Gazley *et al.* (2020) published a study on a novel orogenic exploration approach. It used normalisation techniques on mineralisation pathfinder elements in soil from New Zealand as a test case. Rogers *et al.* (2020) presented findings of soil geochemical baseline studies between New Zealand and the Loyalty Islands, New Caledonia, at a New Zealand conference.

GNS Science (the New Zealand Earth, geoscience and isotope research institute) is in the second year of a five-year programme (2019-2024) that is, in part, funding geochemical baseline in soil studies. Collaborative efforts are underway amongst several New Zealand universities and institutions to collect further geochemical baseline in soil samples as part of this programme. Collaborations involve post-graduate studies to understand the implications of heavy metal and isotope distribution through soil and community science projects. New Zealand has been in a sample and data collection phase in 2020, with results expected in late 2021 and beyond.

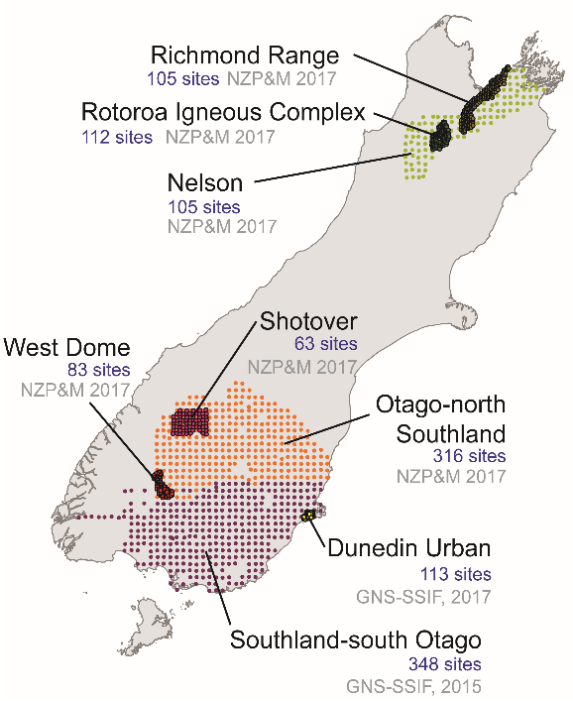


Figure A5.23. Sites currently collected at multiple depths across the South Island of New Zealand. More sites on both islands are planned to be collected in 2021.

A5.5.2.1. Published articles, papers, atlases and books

Gazley, M.F., Martin, A.P., Turnbull, R.E., Frontin-Rollet, G., Strong, D.T., 2020. *Regional patterns in standardised and transformed pathfinder elements in soil related to orogenic-style mineralisation in southern New Zealand*. Journal of Geochemical Exploration 217, 106593, 20 pp.; https://doi.org/10.1016/j.gexplo.2020.106593.

A5.5.2.1. Oral and poster presentations

New Zealand Trace Elements Group TraceNZ Conference. 10-11 February 2020, University of Waikato, Hamilton, New Zealand:

Rogers, K.M., Turnbull, R.E., Martin A.P., Rattenbury, M.S., Rakowsji & D., Jeanpert, J. *Geochemical baseline soil surveys from New Zealand and Loyalty Islands*.

A5.6. EUROPE

A5.6.1. EuroGeoSurveys Geochemistry Expert Group

Report by Philippe Négrel, Anna Ladenberger and Jasper Griffioen (EuroGeoSurveys Geochemistry Expert Group; p.negrel@brgm.fr; anna.ladenberger@sgu.se; jasper.griffioen@tno.nl)

The main activities of the EuroGeoSurveys Geochemistry Expert Group (EGS-GEG) during 2019 were:

- Advisory work for the European Environmental Agency (EEA): The EGS-GEG Chairpersons have been invited as experts by EEA (Eionet NRC Soil) to contribute to the new European Soil Condition Assessment 2020/2021.

- Participation in the virtual EGU 2020, Vienna, 4-8 May 2020: Session BG1.6 - *Functions and functioning of the Critical Zone*. Virtual Zoom session open to EGS members but due to Covid-19 there were few attendees.
- Comment on the new European Union (EU) initiative '*Healthy soils – new EU soil strategy*': Healthy soils are essential to meet climate and biodiversity goals under the European Green Deal. Part of the EU biodiversity strategy for 2030, this initiative will update the current strategy to address soil degradation and preserve land resources ('land degradation neutrality'). The goals are to:

  - ✓ protect soil fertility
  - ✓ reduce erosion and sealing
  - ✓ increase organic matter
  - ✓ identify contaminated sites
  - ✓ restore degraded soils, and
  - ✓ define what constitutes 'good ecological status' for soils.

  It is worth reading the submitted comment because it is related to the work of the IUGS Commission on Global Geochemical Baselines: '*The EuroGeoSurveys Geochemistry Expert Group (EGS GEG) welcomes and adheres to the new EU soil strategy roadmap. The evaluation of European soils is a very complex task that involves many scientific disciplines. European countries have extensive experience and knowledge in the assessment and research of soil condition. However, common harmonized policies and strategies are still missing.*

  Developing a new soil strategy will require a broad network of experts who can support the work and the actions to be taken.

  The EuroGeoSurveys Geochemistry Expert Group has broad expertise in assessing the biogeochemical quality of soil at both national and pan-European scales. The chemical quality of soil, and other environmental media such as water, sediment, subsoil and made ground vary according to natural geoenvironmental processes and anthropogenic activities. We encourage the consideration of subsoil and made ground as soil-type media. In many Member States there are significant accumulations of subsoil deposits which have important functions that need to be protected and assessed. Subsoil, although less vulnerable to degradation than topsoil, also needs to be protected from degradation to prevent risks to environmental quality and human health, most notably contamination. Made ground forms the upper horizon of urban soils and is typically poorly mapped and understood at city level. Urban soils are known to be sinks for contaminants including metals and persistent organic pollutants and are significant for human health and environmental quality.

  The natural baseline of these materials must be established in order to distinguish point and diffusive contamination from natural enrichments through high natural availability, mineralisation and weathering processes. In our experience and expert opinion, there is a need to develop firstly, soil reference materials to monitor the quality of laboratory results, and secondly the application of standardised sampling and analytical protocols. Such a pan-European project is essential to install strict quality control procedures at all stages (sampling, sample preparation, laboratory analysis). These steps will allow the validation of the quality of generated data and, thus, the production of harmonised data sets that will enable systematic comparison and interpretation to feed land management policies with relevant information.

  We would like to state that there already exist large data sets on soil type and biogeochemical quality at the national, regional and continental scales, which could be assessed and evaluated further. When assessing soil chemical data, it is of utmost importance to consider the various types of soil and land use. Any diffusive and point-

source contamination evaluation has to be compared with the natural baseline, and to our experience is usually a local to regional feature. One must ask the question what the time scale is for monitoring of contamination in order not to overinvest financial means and human resources in actions that will not contribute new information to our knowledge and understanding of the environment.'

- Participation in the virtual meeting on the '*Launch of the EU Soil Observatory - Soil: the living heart of a sustainable and healthy Europe*', 4th December 2020, organised by EU Joint Research Centre.
- 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. One paper was accepted for publication, *i.e.*, GEMAS: *Geochemical distribution of Mg in agricultural soil of Europe*, which was accepted in December 2020 for publication in the Journal of Geochemical Exploration. The work on three other papers is ongoing:

- GEMAS: Chemical weathering of rocks revealed by agricultural soil of Europe: Part 1 – Silicates, and
- GEMAS: Chemical weathering of rocks revealed by agricultural soil of Europe: Part 2 – Carbonates.
- GEMAS: Geochemistry of European black soil.

A5.6.2. Cyprus

Report by Christodoulos Hadjigeorgiou and Andreas M. Zissimos (Geological Survey Department of Cyprus; chadjigeorgiou@gsd.moa.gov.cy; director@gsd.moa.gov.cy; azissimos@gsd.moa.gov.cy)

A5.6.2.1. Geochemical Atlas of Cyprus

Cohen, D.R., Rutherord, N.F., Morisseau, E. & Zissimos, A.M., 2011. *Geochemical Atlas of Cyprus*. University of New South Wales Press Ltd., Sydney, Australia, 144 pp.

The Geochemical Atlas of Cyprus was a five year project (2006-2011), funded through a public tender by the Government of Cyprus, and was implemented in collaboration with the University of New South Wales Australia. The project involved the collection of topsoil and subsoil samples from ≈5500 sites according to the sampling procedure of the FOREGS Geochemical Atlas of Europe, but at a higher sample density. It covered an area of 5,897 km^2 at an average density of ≈1 sample/km^2. The soil samples were analysed for some 60 chemical elements. According to Professor Gerry J.S. Govett, "*the Geochemical Atlas of Cyprus provides a detailed visual record of the distribution of the elements of the periodic table in the soil of a region that has great geological and cultural significance; it is an important contribution to global geochemical mapping*", and he is quite correct because the Geochemical Atlas of Cyprus is unique with respect to the soil sampling density used.

The Atlas was released at the Symposium on the Release of the Geochemical Atlas of Cyprus, which was organised by the Cyprus Geological Survey Department between the 5th and 7th of September 2011 at the Hilton Park Hotel in Lefkosia, Cyprus.

The Cyprus Geological Survey Department is in the process of making available the digital raster maps of all determined chemical elements and physico-chemical parameters, which can be viewed and copied at its GeoPortal. Further, mineralogical data, determined by X-ray diffraction, are provided at 35 sampling sites along a north-east to south-west transect across the Troodos Intrusive Complex.

The four technical reports of the Geochemical Atlas of Cyprus are freely available:

Cohen, D., Rutherford, N., Morisseau, E., Zissimos, A.M., Laffan, S., Gatehouse, S.G. & Ren, L., 2011. *Technical Report on the Development of a Geochemical Atlas of Cyprus: Volume 1 – Text*. The University of New South Wales, Sydney, Australia, 104 pp.

Cohen, D., Rutherford, N., Morisseau, E., Zissimos, A.M., Laffan, S., Gatehouse, S.G. & Ren, L., 2011. *Technical Report on the Development of a Geochemical Atlas of Cyprus: Volume 2 – Tables and Figures*. The University of New South Wales, Sydney, Australia, 261 pp.

Cohen, D., Rutherford, N., Morisseau, E., Zissimos, A.M., Laffan, S., Gatehouse, S.G. & Ren, L., 2011. *Technical Report on the Development of a Geochemical Atlas of Cyprus: Volume 3 – Atlas and Other Maps*. The University of New South Wales, Sydney, Australia, 138 pp.

Cohen, D., Rutherford, N., Morisseau, E., Zissimos, A.M., Laffan, S., Gatehouse, S.G. & Ren, L., 2011. *Technical Report on the Development of a Geochemical Atlas of Cyprus: Volume 4 – Appendix: Analytical Quality Control*. The University of New South Wales, Sydney, Australia, 96 pp.

Inquiries about the availability of the geochemical data sets should be sent to the Cyprus Geological Survey Department.

A5.6.3. Sweden

Report by Anna Ladenberger (Geological Survey of Sweden; anna.ladenberger@sgu.se)

A5.6.3.1. Geochemical Atlas of Sweden

Andersson, M., Carlsson, M., Ladenberger, A., Morris, G., Sadeghi, M. & Uhlbäck, J., 2014. *Geochemical Atlas of Sweden*. Geological Survey of Sweden, Uppsala, Sweden, 210 pp.

The Geochemical Atlas of Sweden is a national compilation of till geochemistry which shows elements' natural background concentrations and their spatial distribution in Sweden. The Geological Survey of Sweden has compiled this geochemical atlas because of the increased demand for knowledge of metals and other elements in the environment.

The book contains maps for 66 elements and pH in till supported by geochemical maps of grazing land (from the GEMAS project) and 14 biogeochemical maps (aquatic plants, SGU database). Detailed map descriptions in Swedish and English follow each map and statistical results are presented as tables in the attachment. The book also contains background information about Swedish geology, mineralisation, and geographical conditions.

The geochemical atlas has a wide range of applications, *e.g.*, in spatial planning including land-use, environmental monitoring, epidemiology, forensic medicine, research, mineral exploration and crisis management.

The complete book of the Geochemical Atlas of Sweden (91 MB) and separate chapters can be downloaded from the SGU website. Single maps and descriptions are available on the Maps and descriptions page. Data and tables can be downloaded from the Data and tables page.

A5.6.4. United Kingdom

Report by Fiona M. Fordyce (British Geological Survey; fmf@bgs.ac.uk)

A5.6.4.1. Stream sediment geochemical atlas of the United Kingdom

Everett, P.A., Lister, T.R., Fordyce, F.M., Ferreira, A.M.P.J., Donald, A.W., Gowing, C.J.B. & Lawley, R.S., 2019. *Stream sediment geochemical atlas of the United Kingdom*. British Geological Survey, Keyworth, Nottingham, United Kingdom, 94 pp. (OR/18/048)

This atlas is a milestone publication representing 45 years of work to characterise the chemical quality of the United Kingdom (UK) surface environment. Maps and information documenting the concentrations of 18 chemical elements analysed in approximately 111,000 stream sediment samples collected across the UK are presented for the first time. Results reveal the influence of natural geological/ weathering processes on sediment chemistry as well as human impacts including urbanisation, industry, mining and agriculture. The data provide an invaluable basis to aid Earth-system process modelling, mineral resource and catchment management, environmental protection and quantitative evidence, against which to measure future environmental change. This atlas has been published as an 'interactive pdf document', which features several functions that allow the reader to access and display different geochemical maps and information in various ways. This atlas is designed to be downloaded and read in two-page view using Adobe pdf software (*e.g.*, Adobe Reader, Adobe Acrobat). If viewed using other software, *e.g.*, within your browser, certain interactive elements may not display or function as intended.

APPENDIX 6: FOREGS PERIODIC TABLE OF RESIDUAL SOIL IN EUROPE