# FOREWORD

The diversity of the Earth's surface geology, and its economic and environmental consequences, has been recognized and studied for more than 200 years. The variability of the surface chemistry of the Earth, and its many implications, has been recognized for a much shorter period of time. The abundances of the chemical elements in the Earth's surface materials are relevant to agriculture, soil fertility, forestry, animal and human health, industrial pollution, mineral resource potential, setting of environmental standards, water quality and land-use planning. An atlas showing the geographic distribution of the elements in common surface materials is the most effective way of summarizing this information. Beyond providing an awareness of the variability of surface geochemistry, large-scale maps in an atlas can reveal hitherto unrecognized geochemical features with geological significance. Contrasts in absolute and relative element abundances between different regions provide evidence to assist in deciphering the geological history of the Earth's continental crust.

Given the many practical uses of spatial geochemical data it is surprising that it was not until the 1980s that the need was recognized for a world-wide geochemical atlas, to complement the many other atlases to be found in every library. Although atlases containing compilations of geochemical data first began to appear in the 1970s, with one exception (Northern Fennoscandia), none extended beyond the confines of a single country. Many applied to only part of a country. The principal barrier to more extensive compilations was that there are many different ways of collecting, preparing and analyzing geochemical samples, and work initiated in different places was undertaken with limited objectives in mind, specific to a project or region. Methods were optimized for a particular purpose, such as exploration for base metals, often within constraints imposed by the limitations of available funding and facilities. Consequently only limited information was obtained. Different projects determined different suites of elements. Even where there were nominal similarities, element abundance data produced by organizations in different countries, or different projects within a country, often could not be compared quantitatively because there was no standardization of the methodologies employed. These problems, which applied to the data collected by national organizations, were even more acute with respect to data obtained in many countries in the course of private sector mineral exploration. Nowhere was there a pool of existing data suitable for reliable large-area compilations.

The first national programmes to collect systematic multi-element geochemical data commenced in the late 1960s. The initiative was mostly taken by existing geological survey organizations. A perceived shortage of uranium provided the justification for the expansion of these activities in the 1970s. Although uranium was the element of primary interest, the opportunity was taken to conduct multi-element surveys, expanding the analytical work to include other elements of potential economic significance, subject to availability of relatively inexpensive analytical facilities. The analytical suite varied from country to country, and as indicated above, there was often considerable divergence in the methodologies applied. The results obtained usually depended on the limitations of the funds and facilities available rather than theoretical desiderata. For example, it was usually not possible to ensure that detection limits were below natural abundance levels for all samples, and difficult-to-determine elements were excluded. So there were gaps and inconsistencies in the data sets obtained, and quantitative country-to-country comparisons could not be made.

Recognizing these deficiencies, and the fact that geochemical features are not confined by national boundaries, informal discussions began among geochemists in the mid-80s to seek ways of rectifying the situation. Almost all previous geochemical mapping projects were planned as an aid to mineral resource assessment, or, where the surveys were sufficiently detailed, directly towards mineral exploration. The environmental implications of the data, although recognized, were not a prime consideration because they were peripheral to the mandate of the geological funding agencies. As a result analytical data concerning elements of major biological concern were often not obtained because additional costs would have been incurred. By the mid-80s the importance of environmental issues was becoming more widely recognized, and geochemists generally agreed that the mapping database in all countries should be expanded to include the whole periodic table. Furthermore, that analytical methods should be used which would ensure the limits of detection were significantly below the normal range of abundance levels.

Initially there were two independent proposals, one, established under the auspices of West European Geological Surveys (the WEGS group) which was focused on Western Europe, and a second proposal, which evolved from an earlier International Atomic Energy Agency (IAEA) exploration research group with a broader membership. The WEGS proposal was based on the collection of overbank samples, a relatively new concept. Members of the latter project, aware that a geological map of the world had been compiled, and that much geophysical data had been assembled as continental scale maps, took a more global view, both geographically and with respect to the methods which should be used. After 1989 the work of the two groups combined and a single objective was pursued. Clearly the first step would be to decide upon the methods which would be suitable for producing a world-wide series of geochemical maps. These would provide standardized quantitative data for all countries and continents.

In 1986 a proposal for an International Geochemical Mapping project was submitted to the governing committee of the International Geological Correlation Programme (IGCP), a creation of UNESCO and the International Union of Geological Sciences. After some hesitation, because of its ambitious aims, the project (no. 259) was accepted, beginning in 1988. Support for the concept was also obtained from the International Association of Geochemistry and Cosmochemistry. The annual funding provided by IGCP, although important in indicating the scientific acceptability of the project and subsidising attendance at meetings, carried only a small proportion of the costs of the project, which were borne by the supporting national geological institutions.

Phase 1 of the project reviewed existing data and methods. The Earth's surface consists of mountains and plains, deserts and rainforests, rocky outcrops and extensive unconsolidated cover, in climatic zones which range from the tropics to the Arctic. With the exception of airborne gamma ray spectrometry, which is only applicable to the determination of radioactive elements, no single data collection method can be applied to every land surface. Regrettably, there is no remote sensing technique capable of measuring all element abundances from a distance, so ground sampling is a necessity.

Consequently many different problems and points of view had to be examined. These included the selection of sample media, sample spacing, the preparation of samples prior to analysis, the analytical procedures to be applied, whether to restrict methods to those involving total extraction of the elements present. If partial extraction was to be used, which method of extraction would be acceptable. The practical management of operations, the handling and storage of samples, quality control and processing of data had also to be considered.

Six years were required to reconcile many different points of view concerning the above issues. The original International Geochemical Mapping project (IGCP 259) became the Global Geochemical Baselines project (IGCP 360). Experimental sampling was undertaken in China, Canada and Fennoscandia to validate the usefulness of very wide-spaced sampling, which was seen as a key factor in obtaining a controlled, systematic, and potentially rapid overview of global geochemistry with economically realistic costs. A necessary by-product of the study was the formulation of an equal-area Global Reference Network for the purpose of sample location and control. The culmination of the work, which had involved discussions with scientists in 35 countries, was the preparation of a report and recommendations. It was published in 1995 (reprinted in 1996) by the Earth Sciences Division of UNESCO (*Darnley, A.G., Björklund, A.J., Bølviken, B., Gustavsson, N., Koval, P.V., Plant, J.A., Steenfelt, A., Tauchid, M. and Xie Xuejing, with contributions by Garrett, R.G. and Hall, G.E.M. 1995: [Reprinted with minor amendments 1996.] A global geochemical database for environmental and resource management: recommendations for international geochemical mapping. Science Report 19, UNESCO Publishing, Paris. 122pp.)*, with financial support from the International Union of Geological Sciences, International Association of Geochemistry and Cosmochemistry, Association of Exploration Geochemists, International Atomic Energy Agency and the Royal Society. Following the publication of the report, in 1996 the International Union of Geological Sciences established a Working Group on Global Geochemical Baselines to encourage, advise and assist in the implementation of the recommendations.

The final chapter of the report is devoted to the problems of implementation. At the time the International Geochemical Mapping project was being launched, the Cold War, which had frozen international relations for 45 years, was ending. Contacts were being established between scientific institutions which had barely spoken to one another for decades. The project was a beneficiary of the enthusiasm and goodwill that emerged. At that time there seemed a reasonable expectation that international scientific projects, especially those relevant to the health of the planet, such as systematic data collection, would be better supported, and be carried to completion. It was expected that there would be a "peace dividend." Instead, national and international budgets for science began to shrink and great expectations did not materialize.

Unfortunately, geochemistry is an orphan subject. Although it touches on many practical issues, from resources to food and health, geochemical data collection is not of first concern to any institution. Unlike meteorology, food and agriculture, or nuclear energy where many types of data collection are a central issue, no prominent world organization, has responsibility for global geochemical issues. Thus, despite the seeming importance of the subject, and its wide-ranging applications, it has proved extremely difficult to obtain funding to undertake the work recommended by an international committee.

After the publication of the report, scientists and institutions in more than 100 countries expressed interest in participating in the assembly of a global geochemical database if funds could be made available. Approaches were made to a number of international organizations, including the UN Environment Program, Food and Agriculture Organization, World Health Organization and IAEA, seeking financial support to execute the recommendations. All pleaded acute budget problems and said that it is the responsibility of national governments to give support to the project. In 1996 matters progressed as far as a UN Committee on Natural Resources formally approving a resolution proposing the establishment of a Global Land Monitoring Program, based on the report's recommendations. Regrettably, matters advanced no further.

Implementation of the recommendations in the report is devolved upon a number of regional committees, under the general guidance of the Working Group steering committee. Each regional committee represents either a group of countries, for example Europe, North America, or single large countries, for example, China, Russia, Brazil, and India. In Europe the Forum of European Geological Surveys (FOREGS) has served as the focus for a regional committee.

The FOREGS Atlas is the product of the European members of the Global Geochemical Baselines project. It represents a major achievement in several respects. It is the first multi-media, multi-element atlas published as a contribution to the Global Geochemical Baselines project. It has been made possible by the financial support of geological institutions and their geochemists in 26 countries. Their wisdom and foresight merit public appreciation. No funding has been received from external agencies. The achievement demonstrates what can be achieved through goodwill and cooperation. However, coordinating voluntary effort is never easy. The need to rely upon donated effort and facilities has placed a continuing burden upon the project's Executive Director, Professor R. Salminen, not only for scientific and technical judgment, but also for diplomatic and negotiating skills. The organization and management of the project has been a difficult, onerous and time consuming task, and he deserves great credit for his persistence and diligence over a period of nine years. His parent institution, the Geological Survey of Finland, which provided supporting services throughout this period, without which the project could not have gone forward, is to be commended for its European spirit. As is apparent from the Introduction to this atlas, the work could not have been accomplished without the enthusiastic participation of many individuals in many institutions. All have played an essential part. They have contributed to the completion of the first instalment of what is intended, eventually, to become a world-wide series of atlases, and as such they are to be congratulated. The need for such a series is long overdue, and it is to be hoped that the example set by this substantial publication will stimulate and challenge organizations in other parts of the world to emulate this European achievement, so that eventually there will indeed be global geochemical baselines.

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Arthur G. Darnley
Honorary Chair,
IUGS Working Group on Global Geochemical Baselines
Geological Survey of Canada
Ottawa, Ontario