



Global scale geochemical mapping program – Contributions from China

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ABSTRACT

Systematic mapping of nearly all elements in the periodic table to cover the entire earth's surface is still a dream for the applied geochemists in the world. Chinese geochemists have been active in the implementation of Global Geochemical Mapping Program. In the past thirty years, a series of systematic geochemical mapping programs have been conducted in China. These programs have greatly contributed to the development of the concept and methodology for the Global Geochemical Mapping Programs, such as the proper sampling medium selection, analytical scheme development, reference material development and also for the establishment of the quality control system. Based on the new sampling concept and encouraging results obtained from the representative experiments conducted in China, a new outline for the Global Geochemical Mapping Program is forwarded.

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1. Introduction

The earth's surface is the interface between the geosphere, pedosphere, biosphere, hydrosphere and atmosphere, and supports human, animal and plant life. Therefore, improving our understanding of the chemical composition and variability of the earth's surface materials at continental and, ultimately global scale is both important and pressing.

It's the dream of many geochemists in the world to obtain a global picture of nearly all the elements in the periodic table. The ultimate aim is a systematic global geochemical database which will have numerous applications, not the least of which will be the preparation of a world geochemical atlas. If this dream is realized, it will be a big event after the discovery of the periodic table by Mendeleev (Xie, 2008).

In 1988 the IGCP Project 259, International Geochemical Mapping, was set up to address the need for standardized geochemical databases worldwide. Detailed recommendations for standardized methods of geochemical mapping were published in the final report of the program (Darnley et al., 1995). The successor project, IGCP 360 entitled 'Global Geochemical Baselines' ended in 1997, and up to now, its work has been carried forward by an IUGS/IAGC Working Group on Global Geochemical Baselines (Smith et al., 2012).

Chinese geochemists have been active in these programs and working group activities. In the past thirty years, a series of systematic geochemical mapping programs have been conducted in China. The

experience obtained from these programs contributed to the solving of the strategical and tactical problems of the Global Geochemical Mapping Program, such as the sampling medium selection, analytical system development, reference material development and also for the establishment of a strict quality control system. China pioneered the use of about 500 floodplain sediment composite samples to cover all of China (Cheng et al., 1997; Xie and Cheng, 1997). Later Bolviken, Bjorklund and Xie made a proposal to have 5000 sampling cells (each 160 km × 160 km) to cover the land surface of the whole world (Fig. 1). This proposal became the content of IGCP 360 (1992–1997) and IUGS/IAGC's Task Group on Global Geochemical Baseline that is ongoing since 1998.

Since the initiation of IGCP 259, more than 20 years have now elapsed, in addition to China, only FOREGS countries, India, Australia, United States and Mexico have the geochemical mapping project covering the areas of these countries and regions. But the aims of these projects were dissimilar and more practical details differed between them. The data obtained from some projects couldn't fully meet with the global comparable requirements. Furthermore, the sampling work is difficult to carry out the same kind of works in South America, Africa and most part of Asia because the lack of funding and the inaccessibility of many GRN cells (160 km × 160 km) in these countries are due to political, cultural and social reasons (Xie and Yao, 2010). In order to obtain a global picture of most element distributions in the foreseeable future, a new mapping concept and a new technique strategy should be worked out and a permanent agency should be responsible to foster geochemical mapping on a global scale (Xie et al., 2011).

The purpose of this paper is to review contributions to the global scale geochemical mapping program made by the systematic

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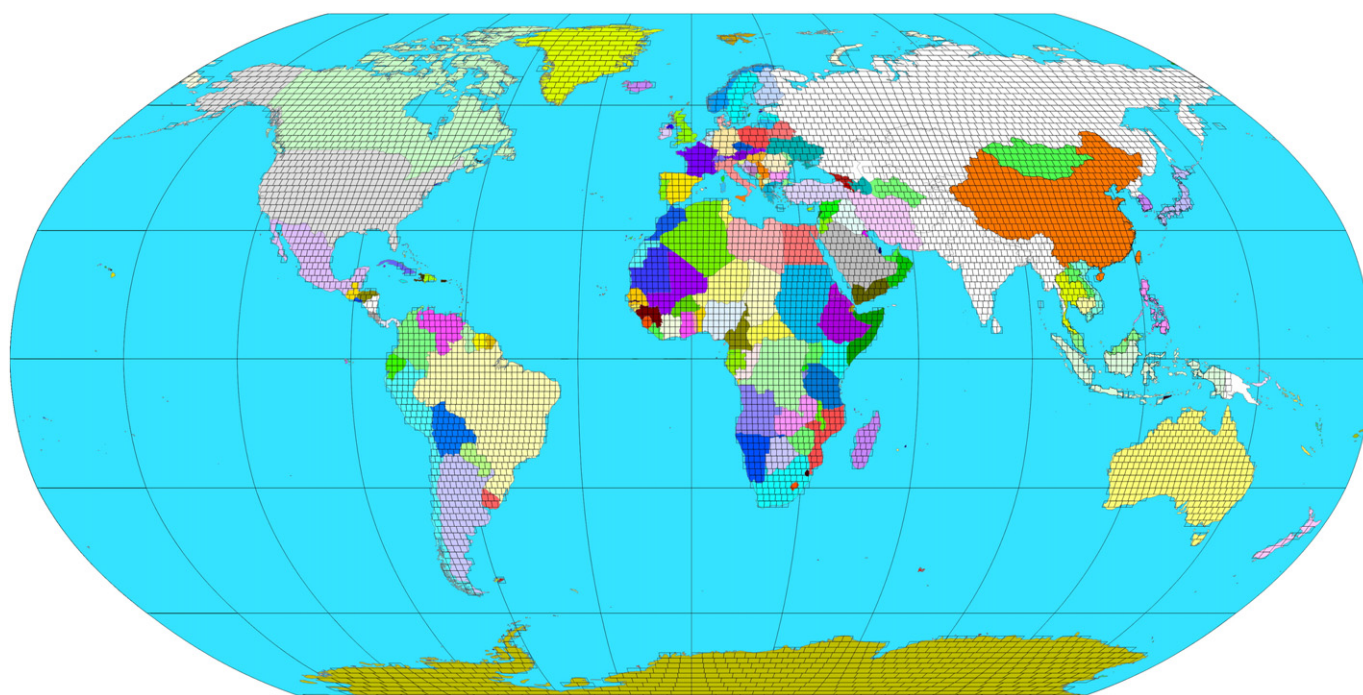


Fig. 1. The global geochemical reference network (GRN) cells covering the Earth land area, based on the grid computations by N. Gustavsson. Gridding data from www.globalgeochemicalbaselines.eu

geochemical mapping programs conducted in China, and to draw the outlines for its future.

2. Systematic geochemical mapping programs conducted in China

In the past thirty years, the systematic geochemical mapping programs and research projects have been conducted with great effort made to develop geochemical exploration methods to cover large areas and even all of China and to analyze more elements with emphasis on high sensitivity and accuracy for analytical techniques. These programs and studies mainly include:

- (1) The Regional Geochemistry National Reconnaissance (RGNR) program: This program initiated in 1979 has now covered about 7.7 million km² (80%) of China's territory by within-cell stream sediment sampling (Xie et al., 2013). The standard stream sediment sampling was performed with sampling density of 1–2 samples/km². The samples in four “sampling cells” were combined into one sample for analysis of 39 elements. The results have been published in *Geochemical Atlas of China* both in English & Chinese (Xie et al., 2012). Fig. 2 shows the silver geochemical map of China based on the RGNR data as an example. The tremendous amount of data for 39 elements has led geochemists to develop the geochemical block concept (Xie et al., 2004) for predicting world-class mineral deposits. About 1900 economic mineral deposits were discovered using the information provided by this program (Xie et al., 2011).
- (2) The 76 Geochemical Element Mapping (76GEM) program: This program using the composite samples of South & SW China derived from the RGNR sample bank (25 samples covering 100 km² were combined together) was finished and will be published soon as an atlas both in English & Chinese. This program successfully established the 76-element geoanalytical scheme for the stream sediments (Table 1). It was the first geochemical mapping project to meet the analytical requirements of IGCP 259 for analysis of nearly all elements in the periodic table (Xie et al., 2011). Fig. 3 shows the osmium

geochemical map of Southern China.

Another key achievement of this program was the advancement of Virtualized Reference maps concept to replace the standard reference samples in monitoring not only the data quality but also the mapping quality as a whole.

- (3) The Multi-purpose Regional Geochemical Survey (MRGS) program: The program initiated in 1999 had covered 1.7 million km² in eastern China by the end of 2012 (Li et al., 2014). The aims of this program are to study the ecological, environmental, and agricultural problems. One surface soil sample was taken in each 1 km² cell and one bottom soil sample at depth of 1 m was taken in each 4 km² cell. Composite surface samples from each 4 km² cell and composite bottom samples from each 16 km² were prepared and submitted to laboratory for analysis of 54 elements (Xi, 2009). The analysis quality control method of the Virtualized Reference Maps concept was successfully applied in this program (Xie et al., 2003). The seamless geochemical map can be compiled directly using the different provincial survey results in which the samples were analyzed in different laboratories and different times (Zhou, 2010). Fig. 4 shows the surface soil sulfur geochemical map of the Haihe drainage basin from which the samples collected in Beijing, Tianjin, Hebei and Shangdong provinces were analyzed in different laboratories.
- (4) The Environmental Geochemical Monitoring Network (EGMON) program: This program was initiated in 1992 and completed before the program IGCP 360 was launched by IGCP. The idea of floodplain sampling was developed in this project (Xie and Cheng, 2001). The surface floodplain sediment sample at 5–25 cm depth and the subsurface sample at 80–120 cm depth were collected at more than 500 sampling sites to cover all of China (Cheng et al., 1997). The similarity of the geochemical maps based on the EGMON data and on the high sample density RGNR data can be seen in Fig. 5 as an example.
- (5) The China's Geochemical Baseline Mapping (CGBM) project: This project, as a part of the Global Geochemical Baselines program, is to document both concentrations and spatial distribution of

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