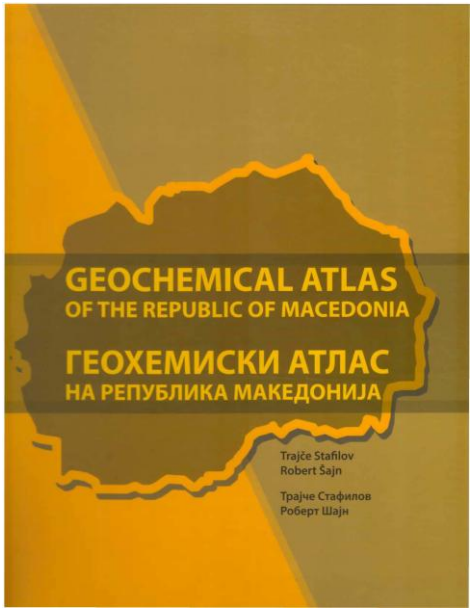
GEOCHEMICAL ATLAS OF THE REPUBLIC OF MACEDONIA

by

Trajče Stafilov and Robert Šajn

The monograph **GEOCHEMICAL ATLAS OF THE REPUBLIC OF MACEDONIA** is the first extended work in which data on the geochemistry of the surface soil in the Republic of Macedonia have been described. This book is written in English and Macedonian to make the information on the mineralogy of the Republic of Macedonia accessible for the readers and experts in the Republic of Macedonia and to a worldwide audience.



Beside the research activities on heavy metal pollution in specific areas in the Republic of Macedonia, information about soil quality on a national level were limited. Therefore, a geochemical investigation of soil across the whole country was performed, and this information deficit is being addressed with this first Geochemical Atlas of the Republic of Macedonia. In this Atlas, the basic geochemical properties of soils are described, as revealed by a detailed large-scale survey across the country and analyses of the findings. It provides the Republic of Macedonia with a sound, well-structured baseline of soil geochemical properties relevant to sustainable land use and soil management and to environmental, agricultural and health-related pressures.

The preparation of this Atlas is the result of a work of Prof. Trajče Stafilov and Dr. Robert Šajn and there six PhD and 18 MSc students as well as the individual experts from the Republic of Macedonia and other countries (Slovenia, Romania and Russia). The Atlas presents a comprehensive picture of the basic geochemistry underpinning life on land, which has resulted from the complex interactions of air, water, soil and human activities. This will aid all those with an interest in the sustainable use of one of the Republic of Macedonia's principal natural resources to make well-informed decisions regarding its management and conservation. It will also assist the Republic of Macedonia in meeting any future requirements under the European Soil Framework Directive. This Geochemical Atlas is the beginning of a process to ensure good quality and scientifically robust information on the state of soil in the Republic of Macedonia. Developing the knowledge and understanding of soil it can ensure that soil and its multiple functions are protected for present and future generations.

The project includes soil sampling and analysis from 1,024 locations with a grid of 5 × 5 km distance between the sampling locations. Each sample represents a mixture of five sub-samples collected in an area of

10 m^2 to the depth of 0–30 cm. Areas which are known as polluted areas (containing mines, metallurgical factories or larger cities) are investigated taking additional samples on a much denser sampling grid. All samples are analysed for the content of about 50 elements. For this purpose, several modern and sophisticated analytical techniques are applied: inductively coupled plasma – atomic emission spectrometry (ICP-AES), atomic absorption spectrometry (AAS), inductively coupled plasma – mass spectrometry (ICP-MS) and neutron activation analysis (NAA). All data are statistically processed and appropriate maps of distribution are prepared for each chemical element.

It should be mentioned that the publishing of the Atlas was supported by the Geological Survey of the Republic of Macedonia preparing the text of geological description of Macedonia.

The book is published in 230×310 cm hardcover format and contains 250 pages. It is divided in 8 chapters: Introduction, Geography of the Republic of Macedonia, Geological Characteristics of the Republic of Macedonia, Pedology of the Republic of Macedonia, Material and Methods, Data Processing, Spatial Distribution of Elements and References. The chapter Geography of the Republic of Macedonia contains 8 maps of the Republic of Macedonia (topographic map, map with the map according to the altitude of the terrain, map with the statistical regions, land use map, map of the average air temperature, map of annual average precipitations, satellite image of the territory of the Republic of Macedonia in the visible spectrum and in the infrared spectrum). Also a simplified geological map of the Republic of Macedonia with 15 geological formations is also introduced in the chapter Geological characteristics of the Republic of Macedonia. In addition to this Atlas the Geological map of the Republic of Macedonia in scale 1:200,000 is applied which is prepared by J. Pendžerkovski and S. Hadži-Mitrova (Geological Survey – Skopje, 1975). Simplified pedological map of the Republic of Macedonia with 13 pedological units is given in the chapter Pedology of the Republic of Macedonia. A map with the sampling sites is also given.

In the chapter Data Processing all important statistical data obtained by data processing are presented including: Descriptive statistics of measurements with many statistical parameters for 39 chemical elements as well as data from multivariate factor analysis and cluster analysis. The obtained factor associations for element contents in topsoil are the following: F1 (Th-Ce-La-Ba-U-K-Be-Rb-Tl), F2 (Fe-Sc-V-Ti-Co-Mn-Cu), F3 (Hf-Zr), F4 (Nb-Ta), F5 (Ni-Cr), F6 (Ca- Mg), F7 (Sn-Pb-Bi), F8 (P-Cd-Zn) and F9 (Sb-As). All of the important obtained geochemical associations of the elements in the country are described: association in connection with the Neogene and Quaternary volcanism (Ba, Be, Ce, Hf, K, La, Rb, Th, Tl, U and Zr); siderophile elements (Co, Cu, Fe, Mn, Sc, Ti and V); association connected with ophiolites and Mesozoic ultrabasic magmatic rocks of Vardar zone (Cr and Ni); chalcophile (sulphide) elements (As, Bi, Cd, Pb, Sb, Sn and Zn) followed with a spatial distribution maps and histograms with a data for the distribution according to the statistical regions and geological formations of the associations of Ce-La, Th-U, Hf-Zr, Fe-Sc-V-Ti-Co-Mn-Cu, Ni-Cr, Sn-Pb-Bi, Sb-As, and P-Cd-Zn.

The chapter Spatial Distribution of Elements contains distribution maps over the entire territory of the Republic of Macedonia with accompying text description followed with a tables and histograms with a data for the mean, median, minimal and maximal values according to the statistical region in the country, 15 geological formations and 13 pedological units. The following elements are included in the atlas: Al, As, Ba, Be, Bi, Ca, Cd, Ce, Co, Cr, Cu, Fe, Hf, K, La, Li, Mg, Mn, Mo, Na, Nb, Ni, P, Pb, Rb, Sb, Sc, Sn, Sr, Ta, Th, Ti, Tl, U, V, W, Y, Zn and Zr. The main goal of the Atlas is to define a geochemical background which could be used for further studies and general monitoring the balance between various geochemical factors, particularly those which are connected with anthropogenic soil pollution. It should be mentioned that such existing phenomena are already registered and described in the Atlas.

It deserves to be noted that this monograph won **the state award "Goce Delčev"** for best scientific achievements in 2016 in the Republic of Macedonia.

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