Lecture Notes in Earth System Sciences

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Geophysical Studies in the Caucasus

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Preface

This book is dedicated to the memory of my teachers, colleagues and internationally renowned geophysicists, Prof. Boris E. Khesin (Azerbaijan – Israel) and Dr. Vyacheslav V. Alexeyev (Azerbaijan – Russia). I began to prepare this book together with Boris, but he died peacefully on November 2010 (see Eppelbaum (2011b)). Vyacheslav passed away tragically earlier in December 1998 in Russia.

The Caucasian Mountains occupy an area of about 440,000 km^2. A number of important mineral resources are concentrated there. Geophysical data on the geological structure of Caucasus can shed light on the basic principles of evolution of the Earth, the distribution of minerals and seismic activity. However, geophysical surveys under complex conditions are generally riddled by poor accessibility to certain mountainous regions, the unevenness of observation surfaces, as well as by the great variety and frequent changes of tectonic structures and geological bodies with variable physical properties. These factors either restrict geophysical surveys in difficult environments or confine the scope of useful information that can be obtained from the results. This has led to the development of special techniques in geophysical surveys, data processing and interpretation that draw heavily on the experience accumulated in the specific conditions of these mountainous regions.

The Caucasian mountain-fold belt is generally considered to have been a result of the interaction of several microplates – fragments of the Afro-Arabian and Eurasian lithospheric plates. Endogenic activity during the Hercynian and Alpine cycles, especially along the boundaries of interacting microplates, caused the formation of a number of large polymetallic, copper, gold-bearing, iron-ore, and other deposits. Within the sedimentary basins there are raw materials for the chemical and building industries. Some of sedimentary basins in the Caucasus and around it contain rich hydrocarbon deposits.

The following conditions are typical for the Caucasus: rugged terrain relief, a highly variable geological medium, oblique magnetization (polarization) and often an unknown level of the normal field. Besides these mountainous conditions that are difficult to traverse, there are also woods, swamps, rivers and lakes. In these areas, the influence of oblique magnetization is of paramount importance since these regions are studied primarily by magnetic survey. Some geophysical investigations have been conducted in small isolated areas (for instance, archaeogeophysical studies), where it is difficult to determine the level of the normal field.

This paints a composite picture of the complexities of Caucasian region. Nevertheless, almost all the methods and geophysical field interpretation procedures described in this book can be efficiently used in simpler geological situations.

The interpretation of geophysical fields in Caucasian conditions remains a challenging process. Successful interpretation calls for (a) knowledge of the geological regularities and the geological situation, (b) availability of petrophysical support, (c) mathematical methods to solve direct and inverse problems of geophysics, and (d) application of statistical, logical-informational, and wavelet procedures to the analysis and synthesis of observational data to reveal specific objects and the peculiarities of geological structures.

This book illustrates the advantages and uses of potential and quasi-potential field interpretation in the complex situation of the Caucasus. The peculiarities of the media and geophysical surveys are discussed. Results show that a common approach to the analysis of geophysical fields that cover magnetic, gravitational and thermal resistivity; self-potential (SP); electromagnetic field of very low frequency (VLF) transmitters and the field of induced polarization (IP) is not only possible but fruitful. This book introduces the reader to the informational content and the structure of interpretation processes developed by the authors. Our methods of reducing various noise effects, especially rugged relief, are exemplified. In particular, several ways of identifying the precursors of earthquakes from the noise background (some of which were developed by the authors) are discussed.

This book not only discusses the techniques recommended for geophysical field transformation and rapid methods of interpretation of anomalies in inclined surfaces and arbitrary polarization of objects. It also describes a process of 3D physical-geological modelling of gravity and magnetic fields in complex environments. It introduces the reader to different variants of integrated interpretation based on probabilistic or deterministic approaches, their reliability estimation and data presentation. The authors of this book (first of all, Boris E. Khesin) worked in the former USSR for many years. They recognized that geophysics in this country had been developing in isolation for many decades. This may help explain why different methods and technologies were simultaneously developed in the East and in the West. Therefore, the references mainly cover the works of Soviet authors. I hope that an acquaintance with this literature will interest Western readers who are conversant with Western investigators' contribution to geophysics.

The authors have attempted to present common overview of Caucasian geophysics that also includes their own work. At the same time I stress that this book should in no way be considered a detailed reference book on Caucasian geophysics since it was not intended to be so.

My goal in this book is interest not only geophysicists, geologists and other environmental specialists working in the Caucasus and students of the corresponding specialties, but also experts investigating other mountainous systems of the world.

Finally, I would like to thank Esther Singer for her detailed careful editing.

Tel Aviv, Israel Lev V. Eppelbaum
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Contents