

# Analytical Methods for Use in Geochemical Exploration

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Volume 5, Number 2, June 1978

URI: [https://id.erudit.org/iderudit/geocan5\\_2br05](https://id.erudit.org/iderudit/geocan5_2br05)

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## Publisher(s)

The Geological Association of Canada

## ISSN

0315-0941 (print)

1911-4850 (digital)

[Explore this journal](#)

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## Cite this review

Armstrong, R. C. (1978). Review of [Analytical Methods for Use in Geochemical Exploration]. *Geoscience Canada*, 5(2), 90–91.

tionalized. Especially near mineral springs resorts sprang up in scenically spectacular mountain areas whereas as late as 1724 the writer of one popular travel book had shown little enthusiasm about the natural landscape and regarded non-cultivated land simply as dreary waste. By 1800 the truth about the Earth was no longer found in books but in the field in the rocks. Thus geology was born and the scientific study of the history of the Earth broke its bonds with written testimony long before the study of human history did the same. That at least is one methodology in which geologists showed the way to go to the historians.

No short review can do justice to Porter's book which, slim as the volume is, packs an impressive number of facts, figures, correlations, working methods and, particularly important, thoughts. The extensive bibliography is of great help to any teacher of the history of science. Now that this is becoming a respectable subject in many universities geologists can be grateful to have Porter as their spokesman among historians.

This book should be bought, read, enjoyed, studied, and referred to in future by all geologists who desire to raise their conscience with respect to their own science. Here indeed are our "Roots".

MS received January 13, 1978

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## Hydrothermal Uranium Deposits

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By R. A. Rich, H. D. Holland  
and U. Petersen  
*Elsevier Scientific*, 264 p., 1977.  
\$34.75 (U.S.)

Reviewed by D. S. Robertson  
and James Tilsley  
*David S. Robertson and Associates Ltd.*  
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The term hydrothermal is "applied to magmatic emanations high in water content; the processes in which they are concerned; and the rocks or ore deposits, alteration products and springs produced by them" (Holmes, 1928).

In the light of this definition, which is common to the understanding of most economic geologists, the book under review is unfortunately misnamed.

The text describes all uranium deposits which are not 'conglomerates', sandstone deposits or 'calcretes' as hydrothermal. While some of the deposits described appear to be, with data presently available, of hydrothermal origin (by the above definition) many, including those of most economic significance, give no evidence of being related to magmatic processes. Indeed, the authors acknowledge the possibility that these deposits are formed from surficial waters (p. 71).

The book is divided into two parts, the first being a review of the geochemistry and mineralogy of 'hydrothermal' deposits while the second provides descriptions of individual deposits from North America, Australia, Europe and Africa.

Part I leans heavily on laboratory analysis and data collected from fluid inclusions. Each of the six chapters making up this section is accompanied by a broad selection of references.

Part II deals with descriptions of 'hydrothermal' deposits in most well known districts. To one familiar with uranium deposits the descriptions are brief to the point of uselessness. Geology of the deposits, in the main, is described in only the most limited way, the descriptions leaning heavily on lists of mineral associations. The lists of reference, again, provide a broad selection.

There is a limited attempt by the authors to provide the kind of synthesis useful to practising mining and economic geologists, those for whom the book purports to be published.

MS received December 23, 1977

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## Analytical Methods for Use in Geochemical Exploration

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By R. E. Stanton  
*Halsted Press*  
(a division of John Wiley and Sons, Inc.)  
54 p. 1976

Reviewed by R. C. Armstrong  
*Cominco Ltd.*  
120 Adelaide St. W.  
Toronto, Ontario

This work succeeds a previous volume by the same author (1966) entitled *Rapid Methods of Trace Analysis*, which dealt exclusively with colorimetric methods of geochemical analysis. Since that time analysis by other analytical methods have become popular and the new volume presents a discussion of these methods. Chapter 1, *Statistical Control of Analysis* (2 p.) deals with a method for the geologist or geochemist to check the reproducibility of the analysis of their samples. The method, called the Craven statistical series, is particularly useful for those with in-house laboratories where once the control samples are established, they can be entered quickly and easily to provide high quality analytical results. The method is not so easily adapted for those who have their samples analyzed in a commercial laboratory. Chapter 2, *Reagents* (2 p.) provided a short description of the properties and dangers of 11 less well known reagents discussed later in the book. Chapter 3, *Methods of Colorimetric Analysis* (19 p.) deals with some of the methods described in his previous book and includes those for metals of current interest in mineral exploration such as Sn, W and Mo. Methods for Bi, B, Pd + Pt, Th and V are also included. The next Chapter on *Cold Extraction Methods of Analysis* (11 p.) briefly explains the use of cold extraction methods in geochemical exploration. Methods for the determination of base metals and As are discussed and, in addition, the concentration ranges covered by the various methods and the productivity in samples per man-day are listed. Chapter 5, *Analysis by Atomic-Absorption Spectrophotometry* (8 p.) begins with a short introduction of the basic principles followed by a discussion of instrumentation (a diagram would have helped) and a presentation of a variety of analytical methods for a large number of elements. The chapter focusses attention on the sample decomposition and briefly describes the chemical reactions which take place. A chapter on *Analysis by X-Ray Fluorescence Spectrometry* (4 p.) discusses the use of this technique in the analysis of As, Bi, Au, Pd, Pt, Se and Te. Procedures for the preconcentration of these elements prior to bombardment are given. The final chapter on *Analysis by Emission Spectrography* (6 p.) was contributed by C. H. James and deals with the application of spectrogra-

phic analysis of geological materials. The basic principles of the technique are clearly presented as are the discussions on instrumentation and sample preparation. Detection limits of elements commonly analyzed are listed and estimates of productivity are given. As well, the problems and the limitations of the method are adequately spelled out to avoid misuse of this powerful analytical technique.

Stanton, in producing this second small volume, provides geologists, chemists and geochemists with a collection of analytical methods for the analysis of geological materials. Although the methods presented are well organized and easy to follow, the book falls short of its stated objective to bring the reader up to date on more modern and rapid methods of analysis. In the preface he states "... analysis by atomic-absorption spectrophotometry has become commonplace, and it is now the leading analytical technique in use for geochemical exploration." Discussion of the method in the following chapters, however, is incomplete (only 8 p.) relative to less commonly used methods of colorimetric analysis (19 p.) and cold extraction methods (11 p.) and occasionally he leaves the reader hanging with statements like "The range of elements that may be analyzed by this method overlaps that of colorimetric procedures, and for some elements the sensitivity is inferior to that obtained by colorimetry", with no follow-up of what the inferiorities might be. Likewise, on the topic of XRF, an overview of the usefulness of this technique in geological exploration would have added greatly. The major use of XRF in North America is for whole rock analysis. Unfortunately, not a word was said of this application. The topic of emission spectrography was well presented but discussions of other multi-element techniques, such as argon plasma methods, would provide an updating of benefit.

In all, this volume will prove interesting reading for those in geological exploration the world over and should be acquired as a companion to his first volume.

MS received February 28, 1978

## **Geostatistical Ore Reserve Estimation: Developments in Geomathematics 2**

By M. David  
*Elsevier Scientific Publishing Co.,*  
364 p., 1977.  
Dfl. 110 (U.S. \$44.95)

Reviewed by Brian W. Hester  
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Geostatistics is a branch of mathematics developed within the last 25 years to explain the distribution and statistical features of mine assays. Much of this work is due to G. Matheron who has developed the mathematical concepts and applied them to a wide variety of data, including assays, which are distributed in a regionalized manner instead of the random one required by classical statistics. Matheron's interest in the peculiarities of these distributions was aroused by papers on assay distributions by De Wijs in the Netherlands and Krige in South Africa published in the early fifties.

The author is both a mining engineer and pupil of Matheron's. For some years he has been associated with geostatistics groups at Ecole Polytechnique, Université du Québec à Chicoutimi, and the Mineral Exploration Research Institute from which he has travelled extensively to lecture on this subject both on this continent and elsewhere. His notes formed the basis for this book which is the first text on this subject in English. Geostatistics has earned widespread acceptance in the North American mining industry only in recent years. This book gives a good overall view of the subject although few of the mining engineers and geologists it is expressly intended for, will follow all the mathematics at the first reading. Some chapters, especially that on Estimating by Kriging, could have been explained at greater length to advantage. The broad principles, however, are laid out fairly clearly throughout the book with many examples from practical situations as well as illustrative computer programmes.

The subject is finding growing use with Canadian mining companies in

solving evaluation problems at all stages of exploration, development and production. It is undoubtedly a major advance in estimation procedures and is here to stay. Any geologist involved with these functions and who is concerned with problems of sampling and estimation of reserves should have this book by his side.

Geostatistics offers a refreshingly new approach to sampling and reserve estimations as well as giving answers to problems never adequately explained previously. Examples of application include the explanation for relatively high grade blocks of ore yielding less valuable mineral than had been estimated from sample results, and conversely. Another is the procedures offered for calculating the best hole spacing for reserve calculations at predetermined confidence limits, and for relating confidence limits of estimates with the size of samples.

The body of the text is concerned with stating the principles and applications of geostatistics, but the first two chapters are devoted to what the author considers are the more useful concepts in classical statistics. This is very well done and about as good a summary as is to be found. Treatment of the 3-parameter lognormal distribution, however, is somewhat cursory in view of its common occurrence in earth sciences. The thirteenth, and last, chapter also digresses from the main subject to discuss statistical problems in sample preparation and crushing before analysis. This is a field not often covered in texts, but again is well presented here. It will be very useful to many readers, especially those not familiar with the works of Pierre Gy and Ingamells. These enable the size of sample to be calculated, as well as degree of crushing and pulverizing for assay values within various confidence limits.

The volume is clearly printed and stoutly bound. Care has obviously been taken in typesetting the mathematical symbols and it is a pity such care was not exercised in editing the text. Certainly, this would have reduced the numerous errors of spelling, punctuation and consistency. Individually, these are trivial, but collectively can annoy the reader and should be corrected in a second edition. There has been a pressing need for a text such as this for some time, so it should win wide acceptance.