

**MANUAL OF THE  
CHEMICAL  
ANALYSIS OF ROCKS**

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Manual of the chemical analysis of rocks by Henry S. Washington

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**HENRY S. WASHINGTON**

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BY  
HENRY S. WASHINGTON, Ph.D.

*SECOND EDITION, REVISED AND ENLARGED*  
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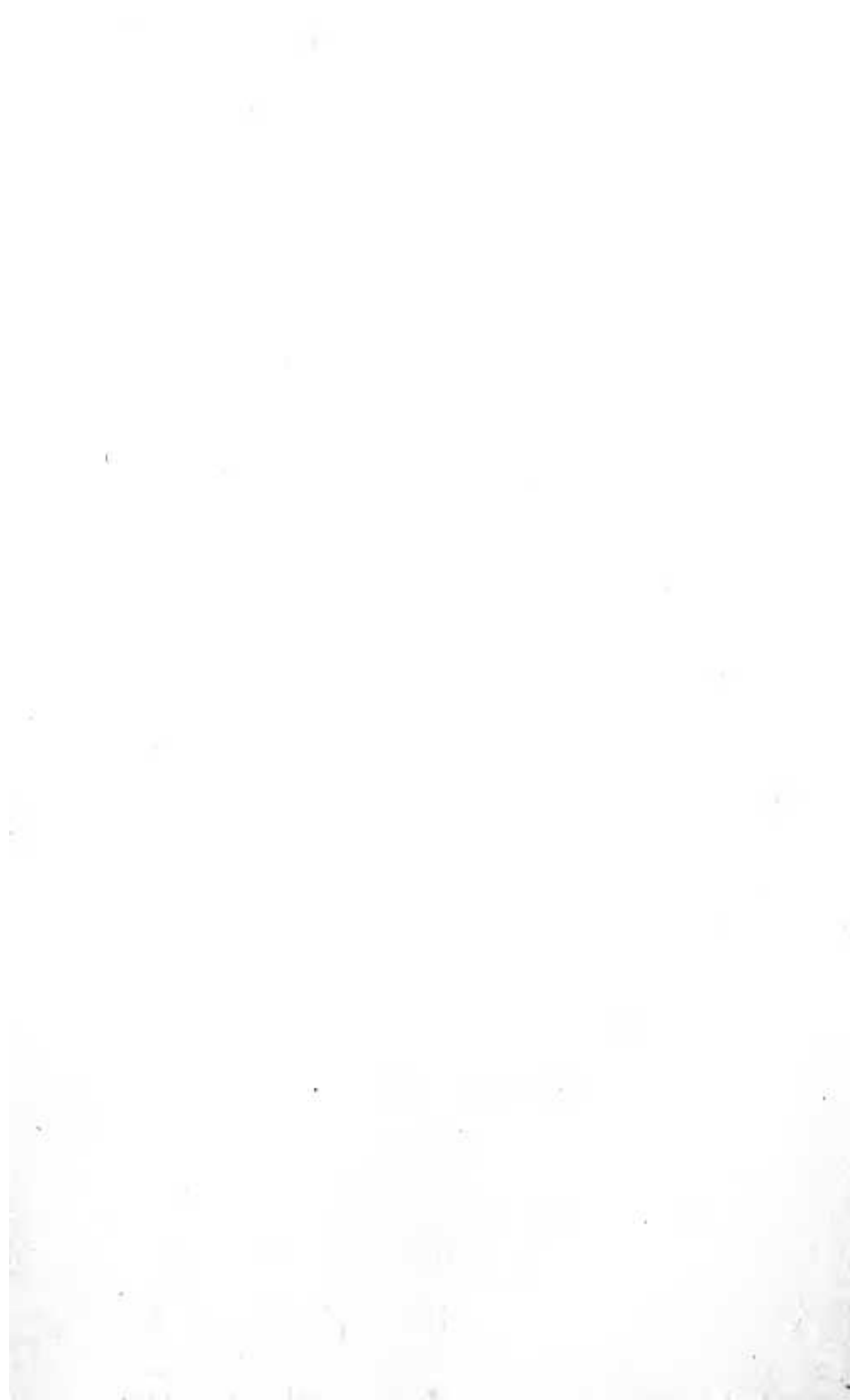
## PREFACE TO SECOND EDITION.

SINCE the publication of the first edition of this book, Hillebrand's largely rewritten and amplified "The Analysis of Silicate and Carbonate Rocks" and a small manual by Dittrich have appeared. To the first of these I am indebted for several new methods, which I have used during the past few years, and which are introduced here, as well as some other methods and modifications in practice from other sources. These supersede or supplement those advocated before. Numerous changes have been made in the text, in part because of new matter or changes in procedure and also because more detail appeared to be needed. The important work of Mauzclius, confirmed by Hillebrand, on the influence of fine grinding, is discussed. The analysis of carbonate rocks, regarded as a special subject, has not been treated, as Hillebrand's latest work covers this fully, and they are of minor importance to the petrologist.

It may be permissible to remark that since 1904 the increase in the number and, still more, the improvement in the quality, of rock analyses have been very great, as will be brought out in a subsequent work. It is hoped that this little book has done its share, along with Hillebrand's invaluable treatise, in aiding to place the science of petrology upon a firm chemical basis, the importance of which is well shown in the recent treatise on igneous rocks by Iddings. I have to record my obligations to Professor J. V. Lewis, for his kindness in undertaking to read the proofs during my absence.

Locust, N. J., January, 1910.

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## PREFACE TO FIRST EDITION.

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THE object of this book is to present to chemists, petrologists, mining engineers and others who have not made a particular study of quantitative analysis, a selection of methods for the chemical analysis of silicate rocks, and especially those of igneous origin. While the publication of such a work may seem superfluous in view of the existence of Hillebrand's treatise on this special topic, yet justification may be found in the fact that the latter is intended, not so much for one who is not very conversant with the subject, as for the practised analyst, to whom it is an indispensable guide.

A further reason for its appearance is that, apart from Hillebrand's book and a paper by Dittrich, there does not seem to exist any separate modern treatise on the chemical analysis of rocks. The space devoted to this branch of analysis in the text-books is usually very small, and the various methods are widely scattered and often inadequately described. This is especially true in regard to the minutiae of manipulation and precautions to be observed, and to the determination of elements which, though usually accounted rare, have of late years been shown to be very common rock constituents. This neglect is rather striking in view of the prominence given in the last decade or so to the chemical composition of igneous rocks.

There is an increasing number of geologists, petrologists, chemists and others, who are desirous of making chemical analyses of rocks, but who have had little or no experience in the

subject, except that gained in the ordinary course of quantitative analysis, in which the study of silicates is usually confined to the examination of a feldspar or some such simple mineral. It is for the benefit of this class of students that the present book is written. The general plan adopted therefore is, not to attempt a complete treatise on rock analysis, but to present only certain methods which have proved simple and reliable in the experience of the chemists of the U. S. Geological Survey and of my own. The more important of these, and some of the principal operations, are described with great explicitness. Many small details of manipulation are gone into which are omitted by Hillebrand and the text-books as unnecessary, a knowledge of them being either presupposed or their demonstration left to the instructor.

In this way it is hoped that it will be possible for an intelligent student, with some knowledge of chemistry and a little analytical training, to be able to complete a satisfactory analysis of an ordinary silicate rock, without personal instruction and after comparatively short practice. To the expert analyst, therefore, the book will contain much that is superfluous, but for this no apology is offered. What are superfluities to him will, it is hoped, be welcome to the novice.

It is assumed that silicate igneous rocks will be the most frequent objects of investigation. At the same time, the methods described serve equally well for most silicate metamorphic and sedimentary rocks. Such rocks as saline deposits, coals and others containing organic matter, are not considered. The methods are not generally adapted to the analysis of ores which, with such constituents as sulphides, arsenides and other compounds of the heavy metals, often call for different and more complex means of separation than are here given. The same is true of many minerals, though the methods found in the following pages are those appropriate to the analysis of most silicates. The analysis of meteorites also demands the employment of special methods, and in most cases these bodies are of such character that their examination should not be undertaken

by the inexperienced, especially if only a limited supply of material is available.

The methods selected are, in general, those adopted by the chemists of the U. S. Geological Survey, and which in their essentials I have employed in my own scientific work for a number of years. Some modifications have been made, chiefly in the direction of simplification and the elimination of certain refinements which do not seem called for when the object of the volume is considered. There is no attempt at the introduction of new methods or the description of alternative ones which, either on theoretical grounds or on account of practical difficulties, are deemed to be less well adapted to the needs of students than those which are here given. Theoretical discussion will be limited to what may seem necessary to make clear the principles of certain methods or the reasons for their selection.

I have also endeavored to point out to the student the importance of chemical analyses for the study of rocks, and their possible bearing on some of the broad problems which form the objects of the science of petrology. In other words, it has been sought to emphasize the fact that petrographical classifications and the study of textures and of minerals in thin sections are not the sole aims of the science, but that, supplemented by a knowledge of the chemical composition of igneous rocks, they are only means to broader ends. I can only express the hope that this little book will aid in the progress of petrology, by leading to an increase in the knowledge of chemical analysis among petrologists and rendering our data in the way of rock analyses of superior quality more numerous.

The great obligations under which I am to Dr. Hillebrand's work are evident throughout and are most gratefully acknowledged. The text-books of Fresenius, Classen, Treadwell, and Jannasch have also been consulted, and the book is indebted to them in many ways. It is also a pleasure to express my obligations to several friends for valuable advice and assistance, and especially to Prof. S. L. Penfield and Prof. L. V. Pirsson, to whom my first knowledge of, and training in, quan-