GEOCHEMISTRY IN MINERAL EXPLORATION

Second Edition

ARTHUR W. ROSE

HERBERT E. HAWKES

JOHN S. WEBB

GEOCHEMISTRY IN MINERAL EXPLORATION

Second Edition

ARTHUR W. ROSE

Professor of Geochemistry,
Pennsylvania State University, University Park,
Pennsylvania, U.S.A.

HERBERT E. HAWKES

Consultant,
Tucson, Arizona, U.S.A.

JOHN S. WEBB

Professor of Applied Geochemistry,
Imperial College of Science and Technology,
London, U.K.

ACADEMIC PRESS
LONDON * NEW YORK * TORONTO * SYDNEY * SAN FRANCISCO
A Subsidiary of Harcourt Brace Jovanovich, Publishers

CADEMIC PRESS INC. (LONDON) LTD
24–28 Oval Road,
London NW1

U.S. Edition published by
ACADEMIC PRESS INC.
111 Fifth Avenue
New York, New York 10003

British Library Cataloguing in Publication Data

Rose, A W
Geochemistry in mineral exploration—2nd ed.
1. Geochemical prospecting
I. Title II. Hawkes, H E
III. Webb, John S
622'.1 TN270 79–50532

Cased edition ISBN 0-12-596250-9
Paperback edition ISBN 0-12-596252-5

Printed in Great Britain by
JOHN WRIGHT & SONS LTD, at THE STONEBRIDGE PRESS, BRISTOL

Preface to the Second Edition

The first edition of "Geochemistry in Mineral Exploration", published by Harper and Row in 1962, was offered as an introduction to geochemistry as applied in exploration for solid minerals. It was addressed to four principal groups of readers: (i) to the student as an introductory textbook; (ii) to the practising exploration geochemist as a source book and reference to the literature; (iii) to the specialized research worker in allied fields, such as environmental or agricultural geochemistry; and (iv) to non-specialized earth scientists who want a source of general information on exploration geochemistry.

The same may be said about this, the second edition. The present volume, however, differs from the first edition in a number of respects. Chemical principles, chemical equilibria, and chemical phenomena relevant to dispersion of elements are strongly emphasized, with the thought that an understanding of these principles will lead to valid new exploration methods and more accurate appraisal of exploration data. Two completely new chapters have been added, on vapor geochemistry and statistical methods. Most other chapters have been thoroughly revised and updated, based on the extensive literature published since the first edition. In particular, the previous single chapters on primary dispersion and on principles of secondary dispersion have each been enlarged into two chapters. Only brief discussions are offered of other fields of applied geochemistry, such as petroleum exploration, agriculture, public health, environmental problems, and forecasting of earthquakes and volcanic eruptions.

So far as practicable, the three approaches to geochemical exploration, namely basic principles, characteristics of geochemical anomalies, and practical surveying techniques, are treated in separate chapters or sections of the book. Thus, the student can learn basic principles in Chapters 6, 7, 8 and 9, and Sections IV of Chapter 2, I of Chapter 3, IV of Chapter 4, and I and II of Chapter 5, whereas Chapters 13 and 16 and Sections VI of Chapter 5, III and V of Chapter 17, and VIII of Chapter 18 are primarily aimed at the prospector or supervisor of a project.

The many friends and colleagues who helped with the preparation of the first edition, and who are listed in the preface of that volume, are again gratefully acknowledged. For this edition, special thanks for critically reviewing individual chapters are due to Fred Ward (Chapter 3), Edward Ciolkosz (Chapter 7), Margaret Hinkle and John Lovell (Chapter 18), and Richard Howarth (parts of Chapter 19). We are indebted to Martin Hale for a review of the entire manuscript and for many helpful suggestions. Numerous other colleagues and students too numerous to acknowledge individually have contributed ideas and stimulation. For care and patience in typing several drafts of the manuscript, we thank Margaret Biggers at Pennsylvania State University. Completion of the text would not have been possible without the sabbatical leave provided to Rose by Pennsylvania State University and the facilities made available to him at the Imperial College.

Although we sincerely hope that this edition is free of inaccurate statements and faulty judgment in interpreting data, we know that this is too much to hope. For these shortcomings, we offer our sincere apologies.

A. W. ROSE, H. E. HAWKES, and J. S. WEBB
August 1979

Contents

Chapter 3

PRINCIPLES OF TRACE ANALYSIS

Chapter 4

PATTERNS OF DEEP-SEATED ORIGIN—ORE TYPES, GEOCHEMICAL PROVINCES, AND PRODUCTIVE PLUTONS

Chapter 5

EPIGENETIC ANOMALIES IN BEDROCK

Chapter 6

WEATHERING

Chapter 7

SOIL FORMATION

Chapter 8

CHEMICAL EQUILIBRIA IN THE SURFICIAL ENVIRONMENT

Chapter 9

MECHANICAL AND BIOLOGICAL DISPERSION IN THE SURFICIAL ENVIRONMENT

Chapter 10

SURFICIAL DISPERSION PATTERNS

Chapter 11

ANOMALIES IN RESIDUAL OVERBURDEN

Chapter 12

ANOMALIES IN TRANSPORTED OVERBURDEN

Chapter 13

GEOCHEMICAL SOIL SURVEYS

Chapter 14

ANOMALIES IN NATURAL WATERS

Chapter 15

ANOMALIES IN DRAINAGE SEDIMENTS

Chapter 16

GEOCHEMICAL DRAINAGE SURVEYS

Chapter 17

VEGETATION

Chapter 18

VOLATILES AND AIRBORNE PARTICULATES

Chapter 19

COMPUTERIZED DATA-HANDLING AND STATISTICAL INTERPRETATION

Chapter 20

GEOCHEMICAL METHODS IN MINERAL EXPLORATION