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**breccias and  
coarse fragmentites**

**petrology, environments,  
associations, ores**

**P. Laznicka**

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DEVELOPMENTS IN ECONOMIC GEOLOGY, 25

# **breccias and coarse fragmentites**

**petrology, environments,  
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**Peter Laznicka**

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*To the memory of my parents*

*To my family*



PLATE 1. Breccias are very cosmopolitan, but in Italy, the cradle of breccias, they almost approach the status of a national stone (after the Carrara Marble, of course!). Exported Italian serpentinite breccias and ophicalcite in the form of polished slabs and tiles, adorn exteriors and interiors of many fine buildings around the world.

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## PREFACE AND ACKNOWLEDGEMENTS

This book was conceived in the early 1980s to provide a single comprehensive review, data source and organizational system covering breccias. It has become soon apparent that the keyword "breccia" represented an extremely heterogeneous population of fragmental rocks including, on one hand, members departing to a considerable degree from the image of a "typical" breccia and excluding, on the other hand, rocks that are breccias in all respects except in name. It has also become clear that breccias can be properly understood only in a broad context that included their unconsolidated equivalents and progenitors. As a result, this book now deals with all coarse fragmentites, although breccias are emphasized.

Because "breccias are everywhere", the environments and associations into which is subdivided the systematic description, coincide with many specialist disciplines and I might be accused of trespassing into fields in which my expertise leaves much to be desired. To put this straight, I would like to say that this is, first, a book devoted to breccias and the rest is auxiliary, but in order to draw comparisons and conclusions regarding the general and universal conditions and controls of breccia origin and occurrence, brief incursions into specialities have been unavoidable. The reader and reviewer should realize that this book has not been intended to be a summary or a substitute for texts in volcanology, glacial geology, carbonate petrology, pedology or meteoritics, because there are numerous works written by experts devoted solely to such a task, to which references are made.

I have been gathering data on breccias for some 15 years. The Canada Department of Indian Affairs and Northern Development sponsored two seasons of fieldwork in the Wernecke Mountains in the Yukon. Thanks are due to Dr. Jim Morin, Dr. R.T. Bell and Mr. Allan Archer for support. Robin Edwards, Craig Chappell, David Gaboury and Brian Carlson cooperated in the field.

The remainder of close to 1,000 breccia occurrences have been visited and studied on my own. I am greatly indebted to numerous colleagues, members of the mining industry, government institutions and academia around the world who guided me on tours, provided shelter or gave advice. Most of the persons acknowledged in my "Empirical Metallogeny" book would qualify. The most recent breccia-related assistance has been received from professors John Guilbert and W.C. Brisbin; from Messrs. D.K. Mustard, N.J. Lehrman, F.J. Menzer, R.K. Preece; R. Bergstrom, Tibor Parák and the LKAB team; Dr. E. Rauhamaki and his Outokumpu Oy. team; Dr. Tom Sibbald, Nick Andrade, and many additional persons and corporations whom I owe a debt of

gratitude. The photographs on pages 564 and 590 are published with permission from Phelps Dodge Morenci, Inc., the property owner.

Professor J.T. Teller provided the much needed collegial encouragement. Dr. Karl H. Wolf in Canberra (formerly with the Laurentian University, Sudbury, Ontario) provided encouragement, additional references, abundant advice and critically read the entire manuscript. It is a pleasant duty to acknowledge contribution of these two friends.

The present academic climate, at least here, is in the grip of grantmanship and does not encourage and support broad scholarship and multidisciplinary syntheses based on scattered pieces of data. As a consequence, I have been on my own financing the frugal travel, typing the camera-ready manuscript on my personal computer, drafting the figures, and enlarging the photographs in my bathroom lab. I hope the reader will find the results satisfactory.

My family: Sarka, Dennis and Paul took an active part in many stages of book preparation, providing company at several breccia-watching expeditions, acting as scale persons and assisting with revisions. They also took over a great deal of my household duties and, worst of all, endured several years of life with a busy father. Thanks.



*"The best breccia specialist  
is a geological generalist."*

## CHAPTER 1

### INTRODUCTION

#### 1.1. BOOK ORGANIZATION

##### 1.1.1. Contents

This book reviews a large body of existing (published) data augmented by new (original) information on coarse fragmental rocks dominated by breccias, but not restricted to them (Figures 1-1, 1-2). It is a reference book providing a comprehensive review of a very broad, interdisciplinary subject in "rock" and "ore" petrology. The emphasis is on the inventory of coarse fragmental rocks and materials in many settings. The book is aimed at practicing field and exploration geologists, students and research geologists to provide them with a standard against which to judge and interpret most coarse fragmental aggregate and breccia occurrences in a local area. Special treatment is given to affiliated metallic accumulations.

Chapter 1 introduces breccias and related rocks as a peculiar geological entity that spans the existing petrographic divisions (sedimentary, igneous, metamorphic), ranging from distinct rock varieties to mere deformation effects superimposed on various preexisting rocks.

Chapter 2 concentrates on petrographic characteristics of coarse fragmentites, their architecture, composition and grain-to-grain relationships. Their transitionality is stressed.

Chapter 3 pays attention to coarse fragmental bodies, their outer shapes and contacts and their internal characteristics. Rudrock facies and congregations of breccia bodies forming higher-order divisions, such as provinces and belts, are reviewed.

Chapters 4 and 5 concentrate on the many mechanisms of coarse fragmentite generation, which span almost the entire spectrum of natural geological processes.

Chapter 6 is devoted to breccia micro- and macrostructures and textures of ore minerals and on the numerous varieties of affiliation of metallic ores to coarse fragmental bodies and systems.

Chapters 7 to 20 review systematically the present geological environments in which coarse fragmentites are forming and the ancient lithologic associations of which they are members.

Chapter 7 deals with the present erosional landforms, surfaces of weathering and depositional basins. Chapter 8 treats recent and ancient carbonates. Silica and silicate sediments and sedimentary rocks mainly detrital but also chemical, are reviewed in Chapter 9.

Chapter 10 deals with evaporites; Chapter 11 with fragmental volcanics and Chapter 12 with fragmentites related to hot spring activity.

Breccias affiliated to granitic terrains and their roof regions are treated in Chapter 13 and Chapters 14 and 15 extend similar coverage to mafic-ultramafic and alkaline igneous associations. In Chapter 16, coarse fragmentites are treated in the framework of tectonites and metamorphic tectonites whereas in Chapter 17 the unifying lithogenetic factor is meteorite impact. In the three remaining chapters are briefly discussed coarse fragmentites of problematic origin and indistinct setting (Chapter 18); anthropogenic fragmentites (Chapter 19) and lunar/extraterrestrial fragmentites (Chapter 20). This is followed by references and several thematic indexes.

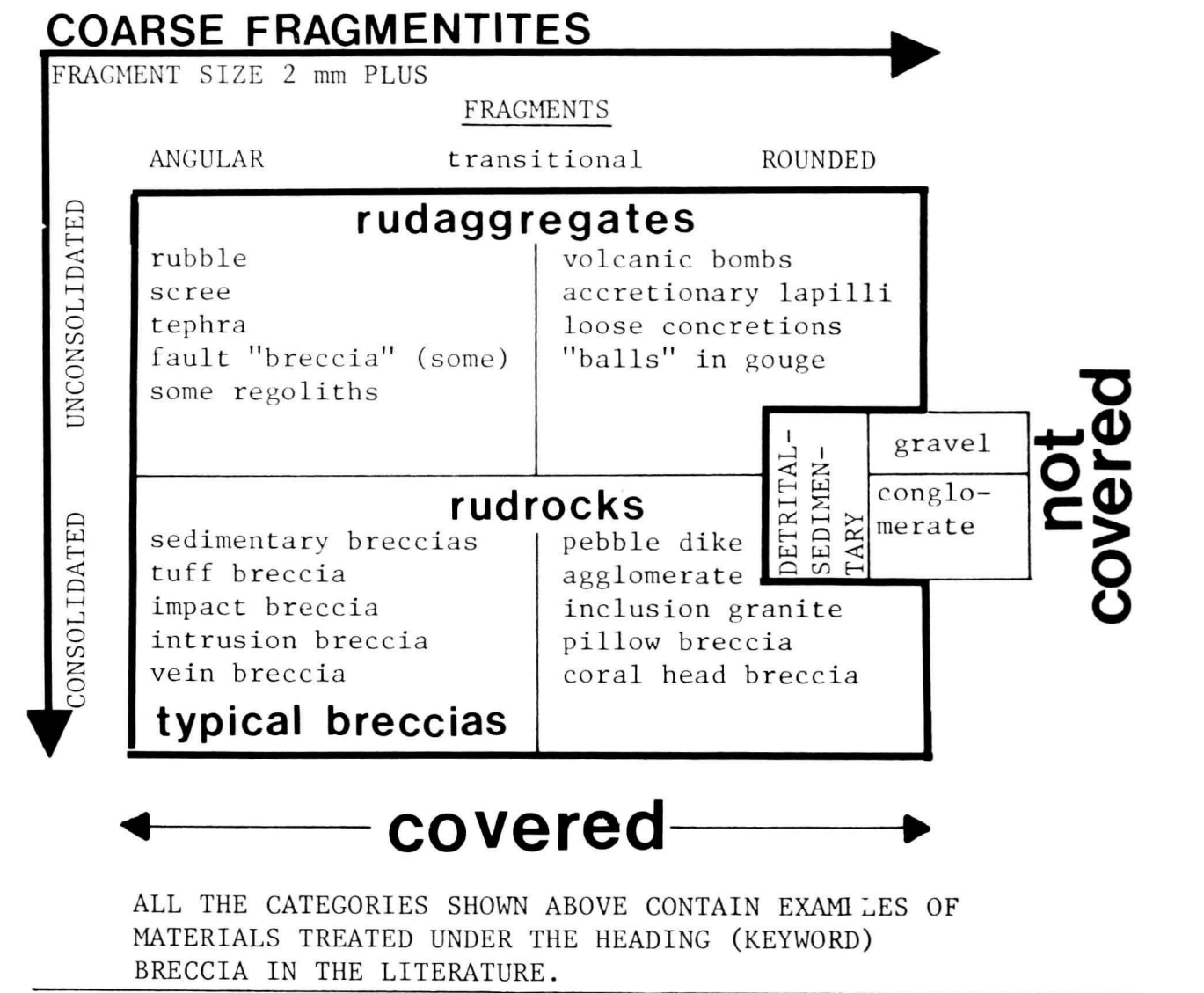
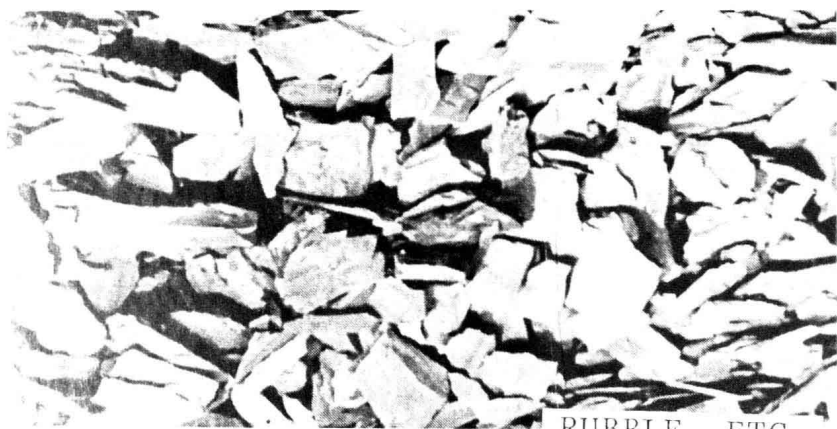


FIGURE 1-1. Coarse fragmentites and scope of this book.

FIGURE 1-2. Photographic representation of Figure 1-1.



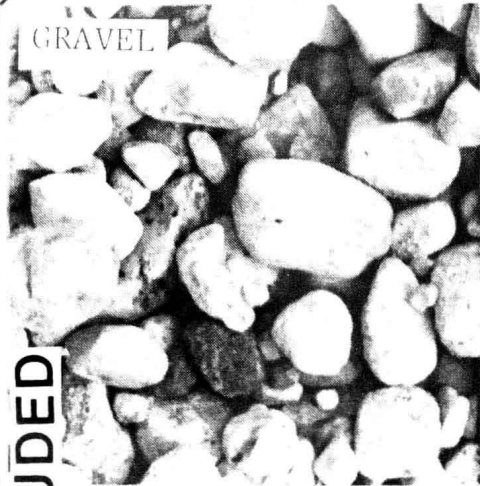
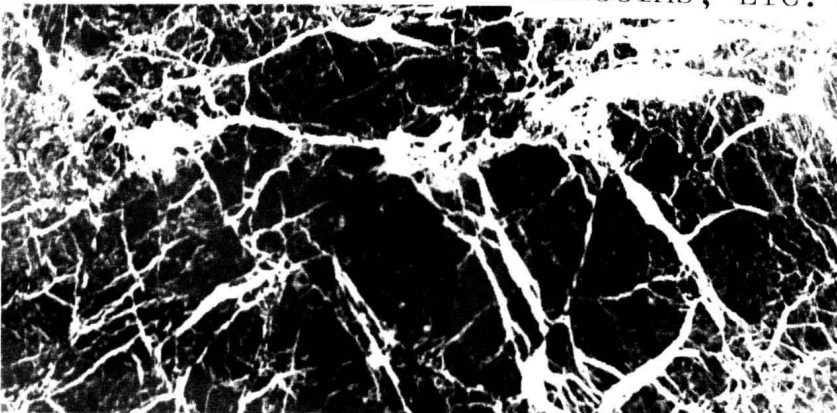
ROUNDSTONE  
RUBBLE, ETC.



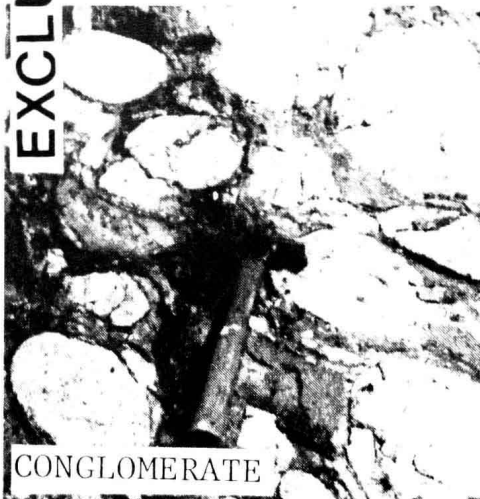
RUBBLE, ETC.



BRECCIAS, ETC.



GRAVEL



CONGLOMERATE

ROUNDSTONE  
BRECCIAS, ETC.

### 1.1.2. Subject and scope

This book deals with coarse fragmental rocks and materials. It puts an emphasis on breccias and their unconsolidated equivalents. This follows graphically from Figures 1-1 and 1-2. Table 1-1 defines terms some of which are new. The reader should note that although a very broad selection of coarse fragmental materials is treated in this book, "typical" clastic sedimentary gravels and conglomerates have been excluded. This is because these materials have an extensive general and specialized literature of their own, which includes reference works available in most world languages. Their incorporation would extend the size of this book beyond reasonable limits.

### 1.1.3. Universal Rudrock Code (URC)

Although the tremendous variety of coarse fragmentites (including breccias) at large makes it almost imperative (at least at present) that their organization, nomenclature and description be made within a restricted genetic or environmental category (e.g. sedimentary, volcanic or meteoric impact fragmentites), certain observable (empirical) characteristics of internal architecture and composition are common to ALL fragmentites and can be objectively recorded regardless of their origin. This is particularly useful when the origin is unknown or questionable. Seven such characteristics constitute the "Universal Rudrock Code (URC; Figure 1-3, Table 1-2) applied, where practicable, in this book. URC can (and has to) be augmented by the more specialized rudrock attributes when such rocks are considered within the context of a particular genetic or environmental system.

URC is presented here early with the intention to serve as a checklist of some of the terms and abbreviations used throughout this book. Additional terms and abbreviations appear, briefly explained, in Tables 1-3 and 1-4.

## 1.2. GENERAL CONSIDERATIONS

### WHY BRECCIAS ?

Breccias are among the oldest rocks recognized, named and listed in the literature. They are among the most peculiar rocks known and some are more (or less) than rocks: they are effects superimposed on other rocks causing minor to major modifications, mainly textural or structural. It has always been difficult to tell where the "normal" rocks (e.g. dolomites), the modified rocks (e.g. brecciated dolomites) and the "real" breccias (e.g. dolomite breccias) commence and terminate and this difficulty is behind the pervasive vagueness in acknowledging breccia presence and recording it in the literature. To many a field geologist, breccias are a nuisance because they can rarely be satisfactorily outlined at the conventional map scales.