GEOLOGIC FIELD METHODS

by

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THE CALIFORNIA COMPANY

HARPER & BROTHERS · PUBLISHERS · NEW YORK

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Library of Congress catalog card number: 57-8063

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HARPER'S GEOSCIENCE SERIES

CAREY CRONEIS, EDITOR

EDITOR'S INTRODUCTION

Julian W. Low's *Geologic Field Methods* is a companion volume to his *Plane Table Mapping* published in Harper's Geoscience Series in 1952. Like that earlier successful manual, Low's *Geologic Field Methods* is an intensely practical, down-to-earth volume designed with the single-minded purpose of being helpful to students, geological trainees, and younger technical employees of companies dealing with economic resources. Its usefulness, however, is likely to be more broadly based. Not only embryonic earth scientists but seasoned professional geologists commonly discover that their academic training in field methods has been inadequate, and that they have overestimated their practical knowledge of the basic logistics of field procedure. Ordinarily this discovery comes late and proves embarrassing to everyone concerned.

Although the foregoing observations would have been sound a score of years ago, they have even sharper pertinence today. This is true because geology is becoming more and more an "exact" science, at least in the sense that precise laboratory experimentation has been increasing while old-fashioned field work has been somewhat on the decline. It thus happens that even under average circumstances an otherwise highly competent modern geologist may have had almost no independent field experience. Yet it is quite possible that such a man may some time be expected to organize and direct a field expedition of considerable complexity. If and when the assignment is made, living and working on the ground in the field will be a necessity despite any or all of the new equipment and methods for conducting every type of areal, stratigraphic, structural, and mineral survey.

Low's manual thus is designed to be a handbook for experienced as well as inexperienced party chiefs. In addition, it should be helpful to party personnel with various levels of training and with different degrees of familiarity with the "country." In fact, the manual is a sort of high level do-it-yourself guide which makes it possible for either the field veteran or the field tyro to follow the step-by-step procedures discussed with very little trouble. The subjects covered have been selected by a master of field methods on the basis of his own rich academic and commercial experience; and Mr. Low has further simplified his straightforward discussions by including scores of highly instructive line drawings, mostly from his own pen.

It is a rare textbook which has been prepared on an outline that will satisfy a majority of teachers of the subject treated. Similarly, manuals used for the instruction of trainees in geology commonly are arranged to suit their authors, not the trainees or their tutors. Hence a serious attempt has been made to make each chapter of the present book essentially independent so that students, teachers, and professional geologists can readily rearrange *Geologic Field Methods* to suit their own ideas of logical development or presentation.

It has long been apparent to the editor that geology must and will place more and more reliance on the exact sciences; but if, in attempting to do so, it inadvertently puts less and less emphasis on meticulously winnowed field data, the results can only range between the mildly misleading and the aggressively worthless. Low's *Geologic Field Methods,* carefully followed, however, should make it possible for quantitative laboratory methods to be based on the soundest of all foundations—accurate field data.

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PREFACE

Geology is primarily a science of correlation, integration, and interpretation; and, like the legs of a tripod, it is supported by the basic sciences of physics, chemistry, and biology, to which we give the geologic names geophysics, geochemistry, and paleontology. In these fields are dozens of worthwhile books and countless papers; and the literature pertaining to them, or more specifically to geology, is growing at an ever increasing rate. No one could hope to read and assimilate all that has been, and is being, published on the subject, and the practicing geologist or student can spend only a small portion of his reading time on subjects not immediately related to his work. It would appear, then, that a new book stands small chance of being read by a substantial number of geologists whose time is so limited, but this is not necessarily so. Every book in geology incorporates much subject matter contained in others. This manual is no exception, for in it can be found little that has not at some time been published. But it is the author's belief that periodically the matter pertaining to one subject should be gathered from many sources, appraised, and then put into a single volume that is "tailored" to fulfill the needs of practicing geologists and students. This applies especially to methods and techniques which have a perplexing habit of becoming lost or forgotten.

The sources of material in this manual are indeterminate. The methods and practices set down here have been collected over a 30-year period of field work, and it would be impossible to recollect those which the writer has improvised and those which have been passed on to him, either by word of mouth or from the written article. In either case, the methods have proved to be practical, and they are hereby passed on to those whose experience and opportunities have been more limited in the applications of field methods.

An attempt is made to present text matter from the viewpoint of the inexperienced man *in the field*, unable to obtain help in the solution of immediate problems. Two objectives have been sought: to limit the dimensions of the manual to a size such that it might easily be carried in a pocket or notebook case, and to display the solutions to various problems in a manner that could readily be correlated with ordinary field situations.

Perhaps too much space has been given to the obvious. If the writer has erred in this respect, it is the result of a desire to reach the man in the field who *most* needs the help. It has been observed that the failure to carry out an assignment effectively often rests not so much on ignorance of the overall plan or background education as on lack of familiarity with minor aspects of methods and procedures. In short, a sharp distinction is made between the *collection* of accurate field data and their ultimate utilization.

This book would have failed to reach one of its primary objectives—small size—if the field *recognition* of geologic phenomena were treated in any detail. It is assumed that various courses in geology will have prepared the novice field geologist in characteristics of geologic phenomena and that his general knowledge will provide the means of distinguishing one type of feature from another. Once the feature is recognized, the methods described will come to his aid in making the necessary measurements. Clearly this manual is not intended to supplant other standard text books on structure, stratigraphy, or the broad subject of field geology. As the title states, this is a manual of methods, and therefore it supplements other standard works.

A realistic appraisal of field work must consider all factors that materially affect the performance of field personnel. The main problems of conducting a survey may not be geological, yet their solution determines to a large extent the success of the venture. This fact is proffered as justification for including such subjects as organization, selected subsurface methods, and outdoor work. Some geologists have never cooked a meal or spent a night in wilderness country; and when faced with these necessities, they find the problems related thereto far surpass those concerned with geology.

Many persons have contributed something to the writer's "bag of tricks," but in most instances the "trick" and the identity of the donor have become separated. Although these associates cannot be specifically named, they have indirectly contributed to the

effort. Especial thanks are due Robert H. Carpenter, who prepared Chapter VIII on field methods for mineral exploration. Many of the figures in the chapter treating field mapping methods were taken from *Plane Table Mapping* (Harper, 1952). Other photographic illustrations were provided by Joe L. Low, and L. W. LeRoy, who are aware of my appreciation.

J. W. L.

March, 1957

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CHAPTER I

Introduction to Surface Geological Investigations

1. General Remarks

Geology is, literally, as "broad as the earth and as high as the sky." As a science it borrows from, and rests upon, all the other natural sciences, and thus it is as complex as the other sciences are complex. Advances in any of the basic sciences directly or indirectly affect the science of geology; and for this reason the ramifications of geologic work must extend into the depths of fields such as astronomy, chemistry, nuclear physics, and biology for newly discovered facts that might aid in solving geologic problems.

In an effort to reduce the vast complexity of geologic science to simpler terms and better organized methods of attack, certain categories of endeavor have developed. Unfortunately, these categories are not founded on common basic principles, and as a result they are not of the same system of classification. Nevertheless, the subdivisions do have a useful and practical purpose, both in the conduct of investigations and in discussion of geologic events and processes. It is well to keep in mind that sedimentation is the result of some tectonic event, that the *expression* of structural processes may vary according to changes in the sedimentary rocks involved in deformations, that climate has a bearing on the types and quantities of sediments deposited and the distribution of existing rocks, and that the chemistry of the seas and the atmosphere will have had considerable effect on the rocks and their organic constituents.

It is evident that stratigraphy is concerned primarily with the characters and relationships of sedimentary rocks and that structure applies to their deformation. These terms, and many others, have geologic connotations. But when we speak of *surface* geology and *subsurface* geology, we are referring to *methods* and realms of observation. The boundaries between the two are broad and indefinite, and geologic interpretations recognize none. In the strictest sense surface geology deals with outcropping bedrock, and subsurface geology with the rocks that are concealed by alluvium, soil, and other recent mantle materials. In practice, however, surface geology may incorporate observations of bedrock made in pits, trenches, mines, and shallow wells; whereas subsurface geology relies almost wholly on data gotten from relatively deep wells. Each method has its advantages and its limitations. In outcrops the characters of rocks over some lateral distance can be observed directly. Unconformities, lithologic changes, lenticularity, degree of dip, and direction of strike are commonplace observations. But rocks at the surface are subject to drastic alterations, depending on the type of rock, climate, topography and other factors. Furthermore, the actual depth of observation is determined by the amount of topographic relief, and the stratigraphic depth to which examinations may extend is limited by surface relief and structure and particular relationships between the two. In contrast, wells drilled for oil are now reaching depths in excess of 20,000 feet. There is no place on the surface of the earth where a *vertical* column of sedimentary rocks approaching such a thickness can be viewed, and it is far from a proved fact that some of the great *compiled* surface sections actually are representative of a restored vertical section at any one point.

The task of the surface geologist does not end with a record of only directly observable features. Dips and strikes and elevations on recognizable stratigraphic units may constitute all that is required as field data for a structural map of an area; but from these data, the geologist must project into the *subsurface*. It should be emphasized that all geologic relationships below the surface—structural and stratigraphic—are inferential, and that a number of assumptions are made in order to project surface observations into the subsurface. Although the extension of surface geology to moderate depths has often produced a remarkably accurate subsurface picture, thickening or thinning of formations, unconformities, and other unseen relationships have likewise led the surface geologist far astray in his interpretations. Geologic problems are much the same no matter what method of attack is employed. Surface geology utilizes certain kinds of data and subsurface, different kinds. No thoughtful geologist would attempt to use one method exclusively where both methods could be combined.

2. The Field Geologist

The term *field* or *surface* geologist is used here with reservations, for, as intimated in foregoing remarks, the prefix *surface* indicates nothing more than emphasis on particular types of data and the methods of collecting and processing these data. A field geologist, therefore, is one who seeks, measures, records, analyzes, and interprets data obtained from outcrops. If his abilities were limited to the recognition and measuring of field features, he would indeed be handicapped in the final appraisal of his field observations. Fortunately, most geologists are sufficiently versatile to apply their knowledge and skills to many areas of investigation, field geology being only one phase of inquiry.

Beginning geologists and students of geology commonly look upon work in the field as a career—a career which affords the opportunities of professional prestige and scientific exploration in wilderness regions. There are few, if any, organizations at the present time which offer such a career. The value of field work in geologic education and experience should not be minimized; under favorable conditions much more geology can be learned in the field in a given length of time than in any other branch of