Basic Geological Mapping

FOURTH EDITION

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Basic Geological Mapping

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PREFACE

This book is a *basic* guide to field techniques used in geological mapping. It is meant to be kept in camp with you and even carried in your rucksack in the field. In addition, because no piece of geological mapping can be considered complete until the geology has been interpreted and explained, chapters are provided on drawing cross-sections; on preparing and presenting 'fair copy' maps; and on presenting geological diagrams from your fieldwork suitable for inclusion in your report. A report explaining the geology is an essential part of any field project and a brief chapter on the essentials for writing and illustrating it concludes this book. Some emphasis, too, is given to field sketch-mapping because many reports lack those large-scale detailed maps of small areas which can often explain complex aspects of the geology that cannot be shown on the scale of the field map being used, and which are difficult to describe in words. Attention is also given to field notebooks which are, in many cases, deplorable.

It is assumed that readers of this book have already had at least one year of university or equivalent geology, and have already been told what to look for in the field. Geological mapping cannot, however, be taught in lectures and the laboratory: it must be learnt in the field. Unfortunately, only too often, trainee geologists are left largely to their own devices, to sink or swim, and to learn to map for themselves with a minimum of supervision on 'independent' mapping projects. It is hoped that this book will help them in that task.

John W. Barnes, Richard J. Lisle, 2003

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John W. Barnes, 2003

1
INTRODUCTION

There are many kinds of geological map, from small-scale reconnaissance surveys to large-scale detailed underground mine maps and engineering site plans, and each needs a different technique to make. Here, however, we are concerned only with the rudiments of geological mapping. The intention is to provide basic knowledge which can be built upon. We cannot tell you everything you need to know but we hope we can stimulate your imagination so that you can adapt your methods to most prevailing field conditions and to the scale and quality of your topographic base maps and, where necessary, to develop and devise new methods of your own. As a geologist, you must also remember that *accurate* geological maps are the basis of *all* geological work, even laboratory work, for it is pointless to make a detailed investigation of a specimen whose provenance is uncertain. As Wallace said in a 1975 Jacklin lecture: 'There is no substitute for the geological map and section – absolutely none. There never was and there never will be. The basic geology still must come first – and if it is wrong, everything that follows will probably be wrong.'

1.1 Outline and Approach

This book is arranged in what is hoped is a logical order for those about to go into the field on their first 'independent' mapping project. First it describes the equipment you will need; then you are introduced to the many types of geological map you may have to deal with some time during your professional career. A description follows of the different kinds of topographic base maps which may be available for you to plot your geological observations on in the field. Methods to locate yourself on a map are also described and advice is given on what to do if no topographic base maps at all are obtainable.

The next three chapters describe methods and techniques used in geological mapping, including a brief description of photogeology; that is the use of aerial photographs in interpreting geology on the ground. A further chapter is devoted to the use of field maps and those much neglected items, field notebooks.

The last three chapters concern 'office work', some of which may have to be done whilst still at your field camp. They cover methods of drawing

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cross-sections and the preparation of other diagrams to help your geological interpretation. Advice is also given on preparing a 'fair copy' geological map which shows your interpretation of the data from your field map. However, a geological map is not, as is sometimes supposed, an end in itself. The whole purpose is to *explain* the geology of the area and your map is only a part of that process: a report is also needed to explain the geological history of the area and the sequence of geological events. Chapter 10 is a guide on how to present this important part of any geological mapping project.

The approach here is practical: it is basically a 'how to do it' book. It avoids theoretical considerations. It is a guide to what to do in the field to collect the evidence from which geological conclusions can be drawn. What those conclusions are is up to you, but bear in mind what the geologist Lord Oxburgh has said; that making a geological map is one of the most intellectually challenging tasks in academia (Dixon 1999).

1.2 Field Behaviour

Geologists spend much of their time in the open air and more often than not their work takes them to the less inhabited parts of a country. If they did not like open country, presumably they would not have become geologists in the first place: consequently, it is taken for granted that geologists are conservation-minded and have a sympathetic regard for the countryside and those who live in it. So, do not leave gates open, climb dry-stone walls or trample crops, and do not leave litter or disturb communities of plants and animals. When you are collecting specimens do not strip or spoil sites where type fossils or rare minerals occur. Take only what you need. Always ask permission to enter land from the owners, their agents or other authorities; and this includes National Trust areas unless they are specifically known to be open to the public. Most owners are willing to cooperate if they are asked but are understandably annoyed to find strangers sampling their rocks uninvited. Bear in mind that upset landowners can inhibit geological activities in an area for years to come, and this has already happened in parts of Britain. Many other countries are less populated and have more open space, and the situation may be easier, but every country has some land where owners expect people to consult them before working there. If in doubt, ask! (See also the 'Geological fieldwork code' published by the Geologists' Association.)

1.3 Safety

A geologist must be fit if he is to do a full day's work in the field, perhaps in mountainous country, in poor weather, or in a difficult climate, either hot or cold. Geological fieldwork, in common with other outdoor pursuits, is not without physical hazards. However, many risks can be minimized by following fairly simple rules of behaviour, and discretion may often be the

better part of valour when, say, faced with an exposure in a difficult position, for a geologist is often on his own, with no one to help him, should he get into difficulties. Experience is the best teacher but common sense is a good substitute. Field safety is more fully discussed in Appendix I from both the standpoint of the student (or employee) and his supervisor (or employer).

1.4 Ancillary Skills

A geologist should be able to swim, even when fully clothed. If you can swim, you are less likely to panic when you slip off an outcrop into a river; or from weed-covered rocks into the sea or a rock pool; or even if you just fall flat on your face when crossing a seemingly shallow stream. A ford often proves deeper than you thought and not all natural water is quite as pellucid as poets would have us believe. Such accidents happen to most of us sometime. If you are faced by something risky, play it safe, especially if you are on your own.

Geologists should also be able to drive. They sometimes have to ride, too. Horses, donkeys, and especially mules, are still used in some mountainous areas. They can save a great deal of tedious walking and backpacking, and mules in particular can clamber up astonishingly steep and rocky slopes. Field geologists spend a great deal of their time getting from place to place.

1.5 A Few Words of Comfort

Finally, some cheering words for those about to start their first piece of independent mapping. The first week or so of nearly every geological mapping project can be depressing, especially when you are on you own in a remote area. No matter how many hours are spent in the field each day, little seems to show on the map except unconnected fragments of information which have no semblance to an embryonic geological map. Do not lose heart: this is quite normal and the map will suddenly begin to take shape.

The last few days of fieldwork are also often frustrating for, no matter what you do, there always seems to be something left to be filled in. When this happens, check that you do have all the essential information and then work to a specific finishing date. Otherwise you never will finish your map.

2
FIELD EQUIPMENT

Geologists need a number of items for the field. A hammer (sometimes two) is essential and some chisels. Also essential are a compass, clinometer, pocket steel tape, and a handlens, plus a map case, notebook, map scales, protractor, pencils and eraser, an acid bottle and a jack-knife. A camera is a must and a small pair of binoculars can be most useful at times, as is a GPS instrument if it can be afforded (see Section 3.4.9). Sometimes a 30 m tape may be needed and a stereonet. If using aerial photographs you will need a pocket stereoscope; very occasionally a pedometer can be useful, although not essential. You will also need a felt-tipped marker pen and/or timber crayons for labelling specimens.

Finally, you need a rucksack to carry it all, plus a waterbottle, emergency rations, a first aid kit, perhaps an extra sweater, your mobile phone (see Appendix I), and of course your lunch.

Geologists must also wear appropriate clothing and footwear for the field if they are to work efficiently, often in wet cold weather, when other (perhaps more sensible) people stay indoors; inadequate clothing can put a geologist at risk of hypothermia (Appendix I). A checklist of what you may have to pack before a field trip is given in Appendix IV, but this is an exhaustive list to cover various types of geological fieldwork in various climates; refer to it before first setting out to your field area base. A more detailed description of the essentials is given in Figure 2.1.

2.1 Hammers and Chisels

Any geologist going into the field needs at least one hammer with which to break rock. Generally, a hammer weighing less than about $\frac{3}{4}$ kg ($1\frac{1}{2}$ lbs) is of little use except for very soft rocks; 1 kg ($2-2\frac{1}{2}$ lbs) is probably the most useful weight. The commonest pattern still used in Europe has one square-faced end and one chisel end. Many geologists now prefer a 'prospecting pick'; it has a long pick-like end which can be inserted into cracks for levering out loose rock, and can also be used for digging in soil in search of float. Most hammers can be bought with either wooden or fibreglass handles, or with a steel shaft encased in a rubber grip (Figure 2.1). If a wooden handle

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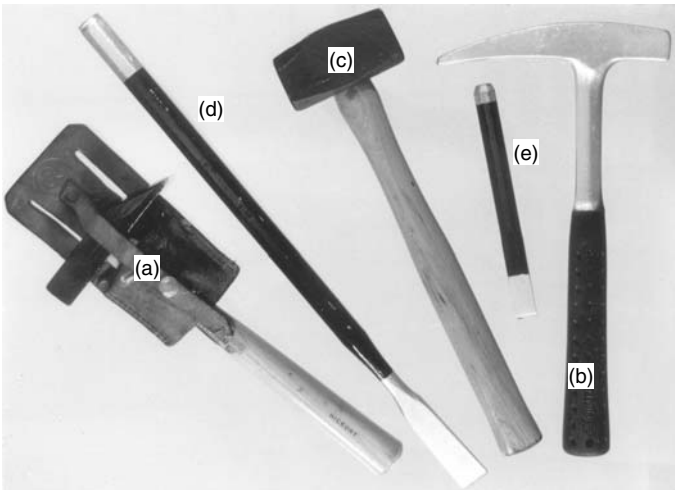

Figure 2.1 *Tools for the field: (a) traditional geologist's hammer in leather belt 'frog'; (b) steel-shafted 'prospecting pick'; (c) bricklayer's 'club' hammer with a replaced longer shaft; (d) 45 cm chisel with 2.5 cm edge; (e) 18 cm chisel with 2 cm cutting edge*

is chosen (it does have some advantages: it is more springy), buy some spare handles and some iron wedges to fix them on with.

Geologists working on igneous and metamorphic rocks may opt for heavier hammers. Although 2 kg/4 lb geological hammers are available, a bricklayer's 'club' hammer, with a head shaped like a small sledge hammer, can be bought more cheaply; but replace its rather short handle by a longer one bought from a hardware store.

Hammering alone is not always the best way to collect rock or fossil specimens. Sometimes a cold chisel is needed to break out a specific piece of rock or fossil. Its size depends on the work to be done. A 5 mm ($\frac{1}{4}$ inch) chisel may be ideal to delicately chip a small fossil free from shale, but to break out large pieces of harder rock a 20–25 mm ($\frac{3}{4}$ inch) chisel is required (Figure 2.1). Perhaps geologists should follow the lead of mine samplers, whose job it is to break off rock and ore and who find a 'moil' more effective. This is a steel bar, usually a piece of drill steel, 25–30 cm long, sharpened to a point and tempered. One thing which you must never do is to use one hammer as a chisel and hit it with another. The tempering of a hammer face is quite different from that of a chisel head, and small steel fragments may fly off the hammer face with unpleasant results.