1
INTRODUCTION

Most geological maps record the regional distribution of rocks belonging to different formations. However, such maps reveal far more than where we could find rocks belonging to a given formation. The geometrical shape of the different formations on the geological map can also be interpreted in terms of the geological structure and geological history of the region concerned. As an earth scientist you must remember that *accurate* geological maps form the basis of most geological work, even laboratory work. They are used to solve problems in earth resource exploration (minerals and hydrocarbons), civil engineering (roads, dams, tunnels, etc.), environmental geoscience (pollution, landfill) and hazards (landslides, earthquakes, etc.). Making a geological map is therefore a fundamental skill for any professional geologist. As Wallace (1975) states, '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.'

There are many kinds of geological map, from small-scale reconnaissance surveys to large-scale detailed underground maps and engineering site plans, and each is made using different techniques. In this textbook, however, we are concerned only with the rudiments of geological mapping. The intention is to provide basic methods and good field practice on which you can further build, and adapt, to deal with a wide range of types of geological mapping.

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. This first chapter includes the important issue of fieldwork safety and appropriate conduct during fieldwork, which should always be considered before anything else. The equipment you will need for mapping is described in Chapter 2, which is followed by a chapter devoted 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 that may be available on which to plot your geological observations in the field. Methods to locate yourself on a map are

Basic Geological Mapping, Fifth Edition.
Richard J. Lisle, Peter J. Brabham and John W. Barnes.

also described, and advice is given on what to do if no topopgraphic base maps at all are available.

The following four chapters describe the methods, techniques and strategies 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 most 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 cross-sections and the preparation of other diagrams to help your geological interpretation. Advice is also given on preparing a 'fair copy' geological map that 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 phenomena found in the area and the sequence of geological events. Chapter 11 is a guide on how to present this important part of the 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 conclusions can be drawn. What those conclusions are is up to you, but bear in mind what the eminent geologist Lord Oxburgh has said about mapping – that making a geological map is one of the most intellectually challenging tasks in academia (Dixon, 1999).

1.2 Safety

DO NOT PROCEED UNTIL YOU HAVE READ THIS SECTION!

Geological fieldwork is not without its hazards. In Britain, field safety is covered by the Health and Safety at Work Act 1974, and its subsequent amendments. Both employers and workers have obligations under the Act and they extend equally to teachers and students.

The safety risks depend on the nature of the fieldwork as well as on the remoteness, weather conditions and topography of the area being mapped. Before starting the mapping project, a formal *risk assessment* should be carried out. This will determine the safety precautions and the equipment to be carried whilst in the field. Table 1.1 lists some common risks, but your risk assessment must also consider the specific dangers associated with the area to be mapped. This will involve doing your homework before leaving for the mapping, for example consulting topographic maps, finding the address of nearest medical services, looking at tide tables, and so on.

Table 1.1 *Common safety hazards associated with geological mapping.*

Risk	Precautions
Fall from steep slopes	Stay away from cliffs, steep slopes, quarry edges, overgrown boulder fields, and so on. Do not rely on Global Positioning System (GPS) but examine a topographic map to identify steep slopes and plan your route. Avoid climbing; leave dangerous exposures unmapped rather than take risks. Do not run down slopes. In mountains but not on a path, stay put in dense mist, fog and darkness
Struck by falling rock and splinters from hammering	Avoid rock overhangs; wear a helmet if near cliffs, quarry faces. Do not enter mines or caves. When hammering always use safety goggles and take care with bystanders and passers-by
Drowning after being swept away by waves, tides and floods	Avoid the water's edge at sea, lakes and rivers. Consult tide tables. Do not enter caves, mines, potholes. Do not attempt to cross fast-flowing rivers
Cannot be reached by emergency services	Work in pairs, or in close association; leave details of the day's route in camp before leaving for the field; wear bright clothing, carry a mobile phone, whistle, torch, flashing LED beacon or a mirror to attract the attention of passers-by or mountain rescue teams
Exposure, an extreme chilling arising from sudden drop in temperature	The symptoms range from uncontrolled shivering, low body temperature, exhaustion and confusion. Carry warm clothing and waterproofs, thermal safety blanket, matches, emergency rations (e.g. glucose tablets, water)
Motoring accident	Drive carefully on narrow mountain roads; at roadside exposures take care with passing traffic and wear high-visibility jackets. Never drive whilst under the influence of alcohol or drugs.

A geologist should be able to swim, even if fully clothed. If you 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. 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. A simple stumble and a broken ankle in a remote area can suddenly become very serious if nobody knows where you are and you are out of mobile phone coverage.

In some northern latitudes (e.g. northern Canada, Svalbard) geologists have to carry guns and flares to ward off the unwanted attentions of polar bears. So if you are planning work abroad, do your homework on special dangers before you go.

1.3 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 being in 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. Therefore, remember the following:

1. Do not leave gates open, climb wire fences or drystone walls or trample crops, and do not leave litter or disturb communities of plants and animals.
2. Do not hammer for the sake of it. Greenly and Williams (1930, p. 289) observe that ‘indiscriminate hammering is the mark of a beginner’ (several key localities once showing beautiful structures have been defaced by geological hammering, drilling and graffiti). When you are collecting specimens do not strip out or spoil sites where type fossils or rare minerals occur. Take only what you need for your further research.
3. Before you embark on any field programme you should have studied your public access rights on footpaths using maps or web-based enquiry. In the UK, you do not have the right to walk wherever you want, but open access to many remote areas is now covered by the Countryside and Rights of Way Act 2000. These are typically areas of mountain, moor, heathland, downland and registered common land; further details can be found on the Ramblers website. When in the field always ask permission to enter any private land when not on a public footpath. Most owners are willing to cooperate with geology students if they are asked politely first; landowners are usually very interested in what lies beneath their land, but understandably get very annoyed to find strangers sampling their rocks uninvited.

If working in a foreign country, carry a simple A5 size laminated card explaining in the local language who you are and what you are doing; this often diffuses any conflict and confusion with landowners due to your poor communication skills. Bear in mind that irate farmers can inhibit/restrict 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 open space, and the situation may be easier, but every country has some land where owners expect you to consult them before working there. If in doubt, ask! (See also the *Geological Fieldwork Code* published by the Geologists' Association, 2000.)

1.4 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 your 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 that have no semblance to an embryonic geological map. Do not lose heart: this is quite normal. Like solving a jigsaw, the first stages are always slow until a pattern starts to emerge; then the rate of progress increases as the separate pieces of information start fitting together.

The last few days of fieldwork are 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 will never finish your map.

Detailed fieldwork preplanning, executing a daily field plan and good time management are often the keys to success.