1 Some fundamentals of geological maps

1.1 Introduction

Geological maps show the distribution at the earth’s surface of different kinds of rocks. The geological map is a fundamental device of geologists. The patterns on the map record the relationships between the rocks, from which the geologist can deduce much about their arrangement underground and about their geological history. This book is aimed at helping you develop these interpretive skills.

A geological map may be a geologist’s first introduction to an area; it may also represent the culmination of investigation. Maps are commonly used to assemble new information as it is obtained; they are also a highly effective way of communicating new data to other geologists. A geological map can act as a synthesis of current knowledge on the geology of an area.

In nature most geological features have three-dimensional arrangements, and a familiarity with them is an essential part of the training of any geologist. The geological map, despite being a flat piece of paper, remains the single most convenient way of representing and working with the spatial arrangement of rocks. The three-dimensional aspect of mapwork is of great industrial use; for example, in dealing with subsurface coal seams, oil reservoirs, and ore bodies. It is a central concern of many of the following chapters.

In both commercial and academic work, maps are much used to help reconstruct the geological histories of areas and the geological conditions that existed in the past. This conveying of information in additional dimensions—underground, and back in geological time—sets geological maps apart from other kinds of maps. Indeed, because so many facts and principles are communicated in a single document, geological maps have been called ‘the visual language of geologists’ (Rudwick, 1976).

Another fundamental difference from most other kinds of maps is that geological maps are themselves based on interpretation. Constructing a geological map involves several interpretive steps, such that the completed map tends to reflect how well the geology of the area is understood. The map acts as ‘an index of the extent and accuracy of geological knowledge at the time of its production, and it is the basis of future research’ (North, 1928).

Geology is increasingly becoming a collection of specialised studies, and more and more specialised kinds of maps are evolving. Nevertheless, the conventional geological map continues to provide a common thread. Most specialisations somewhere involve a traditional geological map. However, geological maps themselves are suddenly undergoing very great changes, especially in the way new technologies are being employed in the production of maps and the manipulation of their information. This adds tremendous flexibility to the ways in which maps can be used, but it also makes an understanding of the basic principles behind them more important than ever. It demands that the geologist appreciates both the power and the limitations of presenting geological information on maps.

This book is largely concerned with these fundamental principles. However, it also attempts to give glimpses of why many geologists, in addition to understanding the functional significance of geological maps, have a fondness for them, and a respect for the heritage they represent. This first chapter introduces the basic features of geological maps, expanding on some of the points mentioned above. We begin with a brief consideration of the topographic base on which the geological map is drawn.

1.2 The topographic base map

Normally the geological data are added to a topographic base map in order that the geology can be located. The base may consist simply of some recognisable features, such as the shape of a coastline or the position of major towns, or the geology may be superimposed on a complete topographic map. Therefore, a first requirement for working with geological maps is a familiarity with the principles of topographic maps, as discussed in standard textbooks on cartography. The most important aspects of topographic maps for geological purposes are summarised in the following sections.
1.2.1 Scale

The scale of geological maps is highly variable: from very small-scale maps of entire continents or even planets, to very large-scale maps which show fine details of a particular locality, perhaps one of special scientific or commercial interest. Scale is most usually specified as a ratio, for example 1:100,000, where one unit on the map represents 100,000 of the same units on the ground. Thus 1 cm on a map at this particular scale would be equivalent to 100,000 cm, that is 1000 m or 1 km. Examples of the kinds of scales typically used for geological maps are given in Fig. 1.1.

Older, non-metric maps were sometimes referred to by a comparative scale, such as ‘one inch equals one mile’. USGS* maps are commonly called ‘quadrangle maps’, as they show a quadrangular area defined by lines of latitude and longitude. The spacing of the lines implies the scale of the map (Fig. 1.1). Maps may also have a linear or graphic scale, that is, a bar or line divided into segments which correspond to specified distances on the ground. This kind of scale is useful in these days of rapid enlargement and reduction of maps by photocopying machines because the scale will still be valid at the modified size.

* United States Geological Survey.
† British Geological Survey.

1.2.2 Map projection

In small-scale maps, say at 1:500,000 and smaller, the way in which the curved surface of the earth has been projected onto the flat paper is important because of the distortions of angles and areas that can result. The various projection methods that are used are summarised in the introductory pages of most atlases; they are considered in detail by Snyder (1987). However, the maps normally used for quantitative geological work are at a sufficiently large scale for the effects of projection to be negligible for most purposes.

1.2.3 Grid systems and location

The direction of north is specified on most maps and is normally towards the top of the sheet. Many maps are divided by a grid system running north–south and east–west to aid in locating particular features. Small-scale maps commonly employ latitude and longitude; large-scale maps may involve some arbitrary but standardised system. For example, the UK uses a ‘National Grid’, summarised in Fig. 1.2. In the USA the most frequently used method of specifying localities remains the ‘township and section’ system (Fig. 1.3). There are, however, increasing attempts to apply the metric Universal Transverse Mercator (UTM) system. This grid already appears on USGS 71⁄2' quadrangles and, together with the National Grid, on BGS† 1:250,000 sheets.