The Field Description of Sedimentary Rocks

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Contents

Preface

The study of sedimentary rocks is often an exciting, challenging and rewarding occupation. However, to get the most out of these rocks, it is necessary to undertake precise and accurate fieldwork. The secret of successful fieldwork is a keen eye for detail and an enquiring mind. Be observant, see everything in the outcrop, then think about the things seen and look again. This book is intended to show how sedimentary rocks are tackled in the field and has been written for those with a geological background of at least first year university or equivalent.

At the outset, this book describes how the features of sedimentary rocks can be recorded in the field, particularly through the construction of graphic logs. The latter technique is widely used since it provides a means of recording all details in a handy form; further, from the data, trends through a sequence and differences between horizons readily become apparent. In succeeding chapters, the various sedimentary rock types, textures and structures are discussed as they can be described and measured in the field. A short chapter deals with fossils since these are an important component of sedimentary rocks and much useful information can be derived from them for environmental analysis; they are also important in stratigraphic correlation and palaeontological studies. Having collected the field information there is the problem of knowing what to do with it. A concluding section deals briefly with facies identification and points the way towards facies interpretations.

Maurice E. Tucker

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1
Introduction

This book aims to provide a guide to sedimentary rocks in the field. It describes how to recognize the common lithologies, textures and sedimentary structures, and how to record and measure these features.

1.1 Tools of the trade

Apart from a notebook (size around 10 × 20 cm), pens, pencils, appropriate clothing, footwear and a rucksack, the basic equipment of a field geologist comprises a hammer, chisel, handlens, compass-clinometer, tape measure or steel rule, acid-bottle, sample bags and felt-tip pen. A camera is invaluable. Topographic and geological maps should also be carried, as well as any pertinent literature.

For most sedimentary rocks, a geological hammer of around 1 kg (2 lbs) is sufficiently heavy. A range of chisels can be useful, if a lot of collecting is anticipated. A handlens is an essential piece of equipment; × 10 magnification is recommended since with this grains and features down to 100 microns and less can be observed. To become familiar with the size of grains as seen through a handlens, examine the grains against a ruler graduated in mm or half mm. A compass-clinometer is also important for taking routine dip and strike and other structural measurements, and also for measuring palaeocurrent directions: correct the compass for the angle between magnetic north and true north. This angle of declination is normally given on topographic maps of the region. You should also be aware that power lines, pylons, metal objects (such as your hammer) and some rocks (although generally mafic-ultramafic igneous bodies) can affect the compass reading, and produce spurious results. A tape or steel rule, preferably several metres in length, is necessary for measuring the thickness of beds and dimensions of sedimentary structures. For the identification of calcareous sediments a plastic bottle of hydrochloric acid (around 10–20%) is useful, and if some alizarin Red S is added, then dolomites can be distinguished from limestones. Polythene or cloth bags for samples and a felt-tip pen (preferably with waterproof, quick drying ink) for writing numbers on the specimens are also necessary. Friable specimens and fossils should be carefully wrapped in newspaper to prevent breakage.

If unconsolidated rocks or modern sediments are being studied you need a trowel and spade. Epoxy-resin-cloth peels can be made in the field of vertical sections through soft sediments. The techniques for taking such peels are given in Bouma (1969).

Other non-geological items which it is useful to carry in the rucksack include: a whistle, first aid equipment, matches, emergency rations, a knife, waterproof clothing and a 'space blanket'.

2
Field techniques

2.1 What to look for

There are six aspects of sedimentary rocks which it is necessary to consider in the field, and which should be recorded in as much detail as possible. These are: the *lithology*, that is the composition and/or mineralogy of the sediment; the *texture*, referring to the features and arrangements of the grains in the sediment, of which the most important aspect to examine in the field is the grain-size; the *sedimentary structures*, present on bedding surfaces and within beds, some of which record the *palaeocurrents* which deposited the rock; the *colour* of the sedimentary rock; the *thickness* and *geometry* of the beds or rock units and of the sedimentary rock mass as a whole; and the nature, distribution and preservation of *fossils* contained within the sedimentary rocks. A broad scheme for the study of sedimentary rocks in the field is given in Table 2.1.

Table 2.1 Broad scheme for the study of sedimentary rocks in the field, together with reference to appropriate chapters in this book

A	Identify lithology by establishing mineralogy composition of rock; see Chapter 3.
B	Examine texture of rock: grain shape and roundness, sorting, fabric and colour; see Chapter 4.
C	Look for sedimentary structures on bedding surfaces and undersurfaces, and within beds; see Chapter 5.
D	Deduce the geometry of the sedimentary rock beds, units and bodies; see Section 5.7.
E	Search for fossils and note types present, modes of occurrence and preservation; see Chapter 6.
F	Measure all structures giving palaeocurrent direction; see Chapter 7.
G	Record details of sequence by means of graphic log and notes and sketches in field notebook; see Chapter 2.
H	Consider, perhaps at later date, lithofacies present, depositional processes, environmental interpretations and palaeogeography; see Chapter 8.
I	Undertake laboratory work to confirm and extend field observations on rock composition mineralogy, texture, structures, fossils (etc.) and to pursue other lines of enquiry such as on the diagenesis and geochemistry of the sediments.

The various attributes of a sedimentary rock combine to define a *facies*, which is the product of a particular depositional environment or depositional process in that environment. Facies identification and facies analysis are the next steps after the field data have been collected. These topics are briefly discussed in Chapter 8.

2.2 The approach

The question of how many exposures to examine per square kilometre depends on the aims of the study, the time available, the lateral and vertical facies variation and the structural complexity of the area. If it is a reconnaissance survey of a particular formation or group then well-spaced sections will be necessary; if a specific member or horizon is being studied then all available outcrops will need to be looked at; individual beds may have to be followed laterally.

The best approach at outcrops is initially to survey the rocks from a distance, noting the general relationships and any folds or faults which are present. Some larger-scale structures, such as channels and erosion surfaces, and the geometry of sedimentary rock units, are best observed from a distance. Then take a closer look and see what lithologies and lithofacies are exposed. Check the way-up of the strata using sedimentary structures such as cross-bedding, graded bedding, scours, sole structures, geopetals in limestones, or cleavage/bedding relationships.

Having established approximately what the outcrop has to offer, decide whether the section is worth describing in detail. If it is, it is best to record the sequence in the form of a graphic log (Section 2.4). If the exposure is not good enough for a log, then notes and sketches in the field notebook will have to suffice. In any event, not all the field information can go on the log.

2.3 Field notes

Your notebook should be kept as neat and well-organized as possible. The location of sections being examined should be given precisely, with a grid reference and sketch map. Any relevant stratigraphic information should also be entered. It is easy to forget such things with the passage of time. Incidental facts jotted down, such as the weather, or a bird seen, can jolt the memory about the locality in years to come when looking back through the book.

Notes written in the field book should be factual, accurately describing what you are looking at, without any interpretations; these can come later when the field data are analyzed. Describe the size, shape, orientation of the features. Make neat and accurate labelled sketches, with a scale. When taking photographs do not forget to put in a scale. Record the location and subject of photographs in the notebook.

One attribute of the sediments which cannot be recorded adequately on the log is the geometry of the bed or rock unit and of the sedimentary rock mass as a whole (Section 5.7). Sketches, photographs and descriptions should be made of the shape and lateral changes in thickness of beds as seen in quarry and cliff faces. Rock units may also change facies laterally. Local detailed mapping and logging of many small sections may be required in areas of poor exposure to deduce lateral changes.

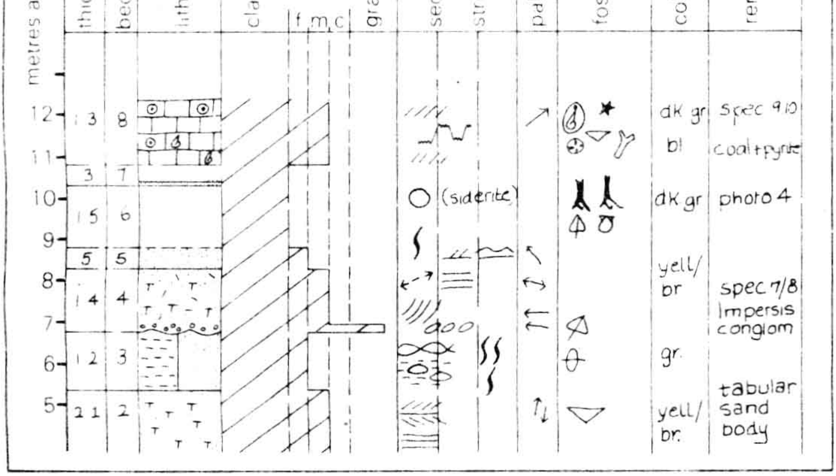
2.4 Graphic logs

The standard method for collecting field data of sedimentary rocks is to construct a graphic log of the sequence (Figs. 2.1 and 2.2). They immediately give a visual impression of the section, and are a convenient way of making correlations and comparisons between equivalent sections from different areas; repetitions, cycles and general trends may become apparent.

The vertical scale used depends on the detail required and available. For precise work, 1:10 or 1:5 is used but for many purposes 1:50 (that is 1 cm on the log equals 0.5 metre) or 1:100 (1 cm equals 1 metre) is adequate.

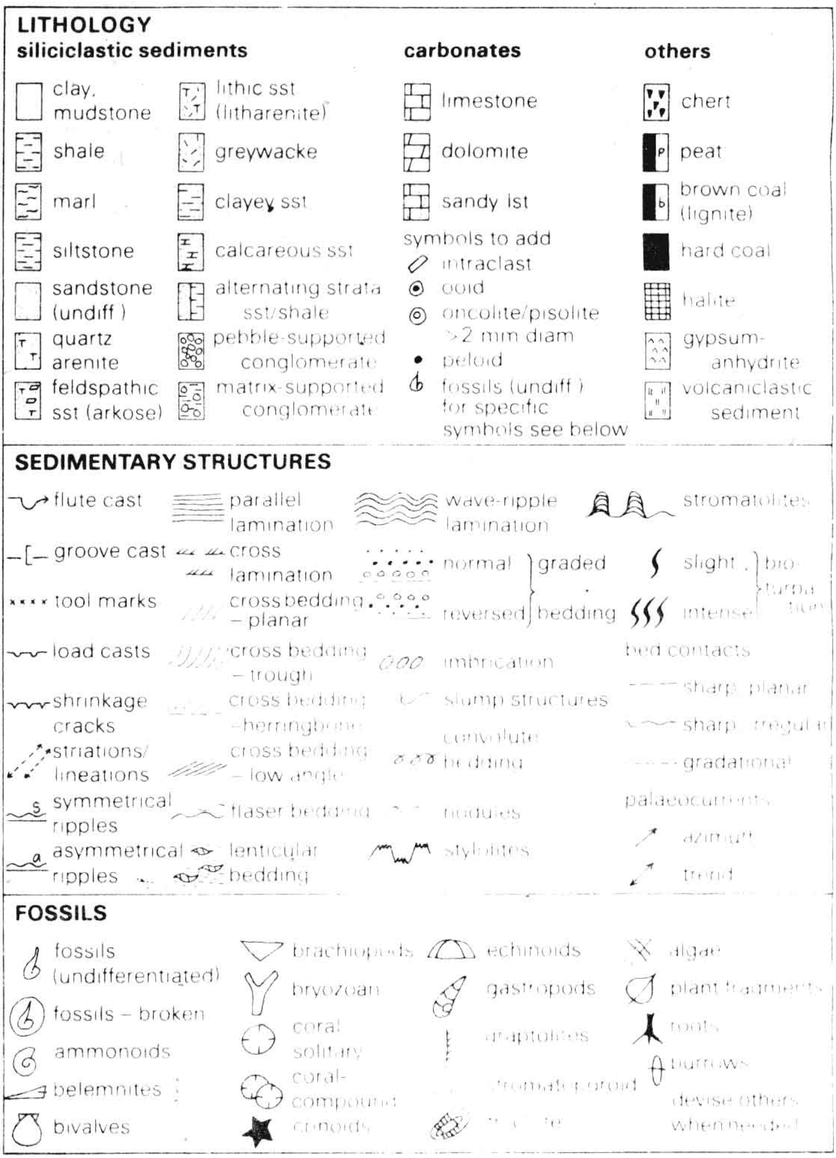
There is no set format for a graphic log; indeed, the features which can be recorded do vary from sequence to sequence. Features which it is necessary to record and which therefore require a column on the log are: bed or rock unit thickness; lithology; texture, especially grain-size; sedimentary structures; palaeocurrents; colour; and fossils. The nature of bed contacts can also be marked on the log. A further column for special or additional features ('remarks') can also be useful. If you are going to spend some time in the field then it is worth preparing the log sheets before you go. An alternative is to construct a log in your field notebook, but this is less satisfactory since the page size of most notebooks is too small.

Fig. 2.1 An example of a graphic log; symbols are given in Fig. 2.2.



Where exposure is continuous or nearly so, then there is no problem concerning the line of the log; simply take the easiest path. If outcrop is good but not everywhere continuous it may be necessary to move laterally along the section to find outcrops of the succeeding beds. Some small

Fig. 2.2 Symbols for lithology, sedimentary structures and fossils for use in a graphic log.



excavations may be required where rocks in the sequence, often mudrocks, are not exposed; otherwise enter 'no exposure' on the log. It is best to log from the base of the sequence upwards.

2.4.1 *Bed/rock unit thicknesses*

These are measured with a tape measure; care must be exercised where rocks dip at a high angle and the exposure surface is oblique to the bedding. Attention needs to be given to where boundaries are drawn between units in the sequence; if there are obvious bedding planes or changes in lithology then there is no problem. Thin beds, all appearing identical, can be grouped together in a single lithological unit, if the log has a small scale. Where there is a rapid alternation of thin beds of differing lithology, they can be treated as one unit and notes made of the thicknesses and character of individual beds noting any increases or decreases in bed thickness up the sequence. It is often useful to give each bed or rock unit a number so as to facilitate later reference beginning at the stratigraphically lowest bed.

2.4.2 *Lithology*

On the graphic log, this is recorded in a column by using an appropriate ornamentation, Fig. 2.2. If it is possible to subdivide the lithologies further, then more symbols can be added, or coloured pencils used. If two lithologies are thinly interbedded, then the column can be divided into two by a vertical line and the two types of ornament entered. More detailed comments and observations on the lithology should be entered in the field notebook, reference to the bed or rock unit being made by its number.

2.4.3 *Texture (grain-size)*

On the log there is a horizontal scale (the textural column), showing clay and silt, sand (divided into fine, medium and coarse) and gravel. Gravel can be divided further if coarse sediments are being logged. To aid the recording of grain-size (or crystal-size), fine vertical lines can be drawn for each grain-size class boundary. Having determined the grain-size of a rock unit, mark this on the log and shade the area; the wider the column, the coarser the rock. Ornament for the lithology and/or sedimentary structures can be added to this textural column. Other textural features, such as grain fabric, roundness and shape, should be recorded in the field notebook, although distinctive points can be noted in the remarks column. Particular attention should be given to these features if conglomerates and breccias are in the sequence (Section 4.6).

2.4.4 *Sedimentary structures and bed contacts*

Sedimentary structures and bed contacts present in the rock sequence can be recorded in a column by symbols. Sedimentary structures occur on the upper and lower surfaces of beds as well as within them. Thus separate columns can be drawn up for surface and internal sedimentary structures if they are both common. Symbols for the common sedimentary structures are shown in Fig. 2.2. Measurements, sketches and descriptions of the structures should be made in the field notebook.

Note whether boundaries are (a) sharp and planar, (b) sharp and scoured or (c) gradational: each can be represented in the lithology column by a straight, irregular or dashed line respectively.

2.4.5 Palaeocurrent directions

For the graphic log, these can be entered either in a separate column or adjacent to the textural log as an arrow or trend line. The measurements themselves should be retained in the field notebook.

2.4.6 Fossils

Fossils indicated on the graphic log record the principal fossil groups present in the rocks. Symbols which are commonly used are shown in Fig. 2.2. These can be placed in a fossil column alongside the sedimentary structures. If fossils make up much of the rock (as in some limestones) then the symbol(s) of the main group(s) can be used in the lithology column. Observations on the fossils themselves should be entered in the field notebook (Chapter 6).

2.4.7 Colour

The colour of a sedimentary rock is best recorded by use of a colour chart, but if this is not available then simply devise abbreviations for the colour column.

2.4.8 'Remarks' column

This can be used for special features of the bed or rock unit, such as degree of weathering and presence of authigenic minerals (pyrite, glauconite, etc.) and supplementary data on the sedimentary structures, texture or lithology. Specimen numbers can be entered here and the location of photographs or of sketches in your notebook.

2.5 Presentation of results

Once the field data have been collected it is useful to consider how these may be presented or communicated to others. Two common schemes involve summary graphic logs and lithofacies maps.

A summary log generally consists of one column depicting the grain-size, principal sedimentary structures and broad lithology; this gives an immediate impression of the nature of the rock sequence, Fig. 2.3. If it is necessary to give more information then lithology can be represented in an adjacent column alongside the summary log.

A lithofacies map shows the distribution of lithofacies of laterally-equivalent strata over an area. Maps can be drawn to show variations in specific features of the facies, such as sediment grain-size, thickness and sandstone/shale ratio.

2.6 Collecting specimens

For much sedimentological laboratory work, samples of hand specimen-size are sufficient, although this does depend on the nature of the rock and on the purpose for which it is required. Samples should be of *in situ* rock and you should check that they are fresh, unweathered, and represen-

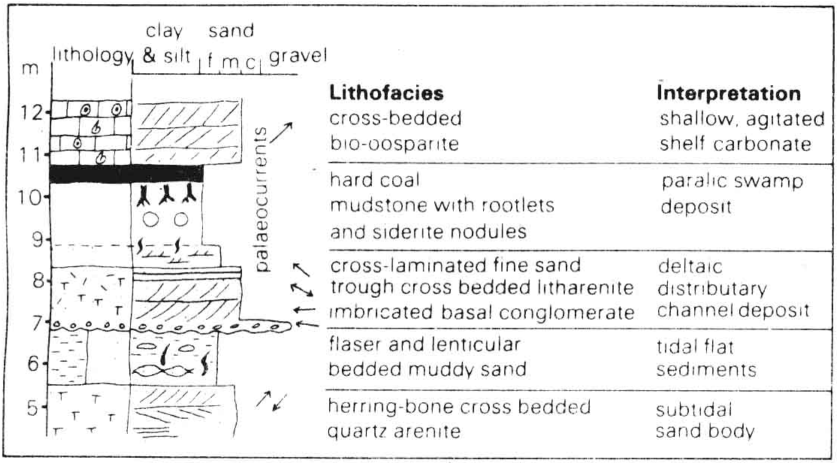


Fig. 2.3 An example of a summary graphic log, based on data of Fig. 2.1.

tative of the lithology. Do not forget to label the rock sample; give it (and its bag) a number using a waterproof felt-tip pen. In many cases, it is useful or necessary to mark the way-up of the specimen; an arrow pointing to the stratigraphic top is sufficient for this. For detailed fabric studies, the orientation of the sample (strike and dip) should also be marked on the sample. As a safeguard, specimen number and orientation data can be recorded in the field notebook, with a sketch of the specimen.

Specimens can also be collected for extraction of microfossils—such as foraminifera from Mesozoic-Cainozoic mudrocks and conodonts from Palaeozoic limestones. A hand-sized sample is usually sufficient for a pilot study. Macro-fossils too can be collected in the field, for later cleaning up and identification. It is best not to collect just for the sake of it: only take away what is really necessary for your project. Ensure you collect representatives of the whole fauna. Faunas from different beds or lithofacies should be kept in separate bags. Many fossils will need to be individually wrapped in newspaper.

2.7 Stratigraphic practice

Stratigraphically, rocks are divided up on the basis of lithology (lithostratigraphy), fossils (biostratigraphy) and time (chronostratigraphy). From field studies, sedimentary rocks are primarily considered in purely descriptive lithostratigraphic terms. The fundamental unit in lithostratigraphy is the *formation*, possessing an internal lithological homogeneity and serving as a basic mappable unit. Adjacent formations should be readily distinguishable on physical or palaeontological characters. Boundaries may be gradational, but they should be clearly, even if arbitrarily, defined in a designated type section or sections. Although thickness is not a criterion, formations are typically 10^2–10^3 m thick. Thickness will vary laterally over an area and formations are often diachronous on a large scale. Stratigraphically adjacent and related for-