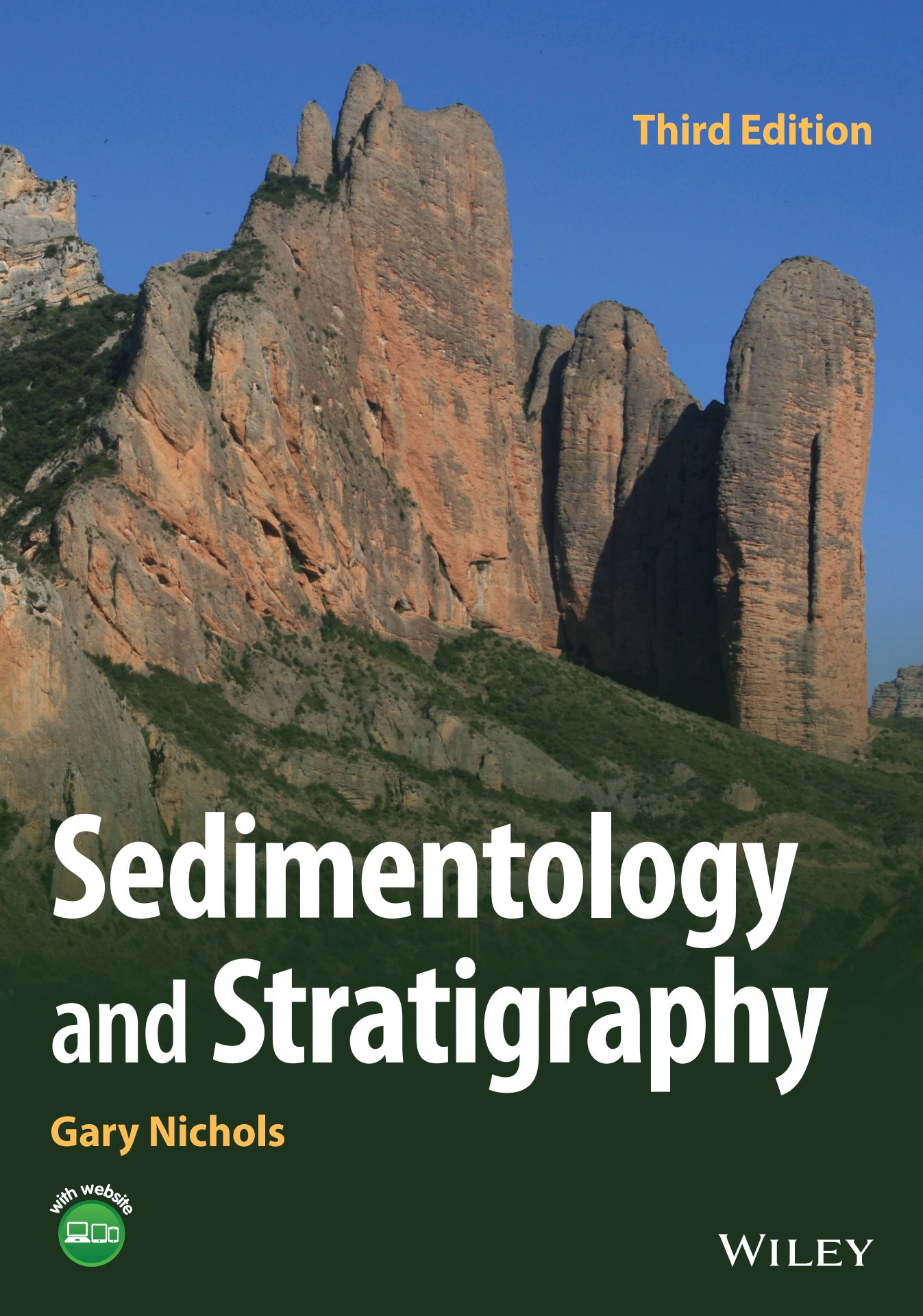
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Sedimentology and Stratigraphy
Gary Nichols
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Sedimentology and Stratigraphy

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Third Edition

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Preface

There is a quote attributed to the late Professor John R.L. Allen, who is regarded as one of the founders of modern sedimentology: '*Geology is not the study of rocks: Geology is the study of processes, the results of which are preserved as rocks*'. John Allen led the way in transforming the earlier descriptive approaches to sedimentary rocks to an analysis of processes and products, essentially establishing sedimentology as a science. A less profound but nevertheless important step change occurred a decade or so later when subsurface studies led to new stratigraphic concepts, turning what had been a framework of names for rock units (lithostratigraphy) into a predictive approach referred to as sequence stratigraphy.

The sciences of sedimentology and stratigraphy as we know them now are only about 50 years old, and much like plate tectonics revolutionised the understanding of the deeper processes in the Earth the subjects are now considered in terms of Earth surface processes and products.

In this new edition of the book, the chapters have been grouped into five parts, A–E, to provide a clearer framework for the different aspects of the subject matter. There has also been a restructuring of the content to make a clearer division between process and product in Parts B and C which cover different environments of deposition. The layout has been modified and higher-quality, colour diagrams and photographs have been included. There is a general update to all subject areas with appropriate general reference materials that have been published in the intervening years since the last edition.

It is always difficult to predict what the nature of the next paradigm shifts in a subject area will be. The purpose of this book is to provide a foundation of understanding of sedimentology and stratigraphy that will hopefully be developed and challenged in the years ahead.

An Undergraduate Text

This book has been written for students who are studying geosciences or Earth sciences at university, and it is intended to provide them with an introduction to sedimentology and stratigraphy. It is hoped that the text is accessible to those who are completely new to the subject area and that it will provide a background in concepts and terminology used in more advanced work.

Definitions of Terms

This book does not contain a glossary, but instead terminology is explained and defined in context within the text. The first occurrence of a technical term is usually cast in *italics*, and it is at this point that the explanation is provided. To find the meaning of a term, the reader should consult the index and go to the first listed occurrence.

Cross-referencing

To minimise the duplication of any material, there is quite extensive cross-referencing, indicated by the chapter/heading/subheading number in italics in parentheses: for example, '(*12.5.2*)' refers to chapter 12, section 5 subsection 2.

References

At the end of each chapter there is a list of further reading materials. They are a selection of publications that can be used as a starting point and are commonly review papers or chapters in more specialised texts. Within each chapter, references to source information have been used sparingly and the references chosen are not intended to be comprehensive for a specific topic.

Acknowledgements

My thanks to the many colleagues and students who I have worked with and who have provided ideas and inspiration throughout my career in geology. Most of that time I have been in the academic world but more recently a spell applying the science to real world problems and training professional geologists has been equally rewarding and informative. I wrote parts of the first edition from a tent in the Antarctic and the second from a small town in the Arctic: during the final stages of this edition my wife Davina has let me hide away in a room in our house on the Isle of Wight, and I have been very grateful for her support throughout. The cliffs behind the beach at Compton Bay on the island were where I first encountered rocks when on holiday as a small child. I don't remember those sandstones and mudstones inspiring me to become a sedimentologist, but I now spend time back on that beach again knowing that there is always more to see, learn and understand. After decades of global geotourism I am back at my geological home.

Diagrams and Photographs

The diagrams have mostly been redrafted from earlier editions with some new illustrations and are now in colour, thanks to the skills of Rouin Dilmaghani of 'graphXcz' in Tábor, Czech Republic.

With a few exceptions noted below, the photographs used in this book were taken by the author. Photos of greater vintage were taken as 35 mm slides and I am grateful for the good services of 'The Slide Converter' company in Essex who created the digital scans. The locations of views and outcrops are provided in the figure captions with the exception of the images at the start of each part and each chapter.

Part A, header: Uluru, Northern Territories, Australia (Cambrian); Chapter 1 header: Grand Canyon, Arizona, USA; Chapter 2: Fig. 2.15 courtesy of Mike Curtis of CASP, Cambridge, UK; Chapter 4 header: Broome, Western Australia (Cretaceous); Chapter 5 header: Isfjord, Svalbard (mostly Carboniferous).

Part B, header: Canyonlands National Park, Utah (Permian); Chapter 6 header: Cordillera del Paine, Chile; Chapter 7 header: Lago Grey, Torres del Paine, Chile; Chapter 8 header: Sahara Desert, SW Libya; Fig. 8.12C courtesy of Martin Stokes, University of Plymouth; Chapter 9 header: Fox Glacier, South Island New Zealand; Chapter 10 header: Lake Natron, Tanzania; Chapter 11 header: Lanzarote, Spain.

Part C, header: Morondava, Madagascar; Chapter 12 header: 12 Apostles, Victoria, Australia; Chapter 13 header: Rotorua, New Zealand; Chapter 14 header: Morondava, Madagascar; Chapter 15 header: Caineville, Utah (Cretaceous); Chapter 16 header: Seven Sisters, Sussex, UK; Chapter 17 header: Amfilochia, Western Greece (Miocene).

Part D, header: Petrified Forest, Arizona, USA;

Part E, header: Annapurna, Nepal; Chapter 20 header: Nizwa, Oman; Fig. 20.5B courtesy of Astrid Blum, CERES International Project, Portugal; Chapter 22 header: Yosemite, California, USA; Chapter 23 Fig. 23.1 courtesy of Dani Guy; Chapter 24 header: South Spitsbergen, Norway; Chapter 25 header: Lauca National Park, Chile.

Front cover: Los Mallos de Riglos, Huesca, Spain (folded Eocene limestones and Miocene conglomerates).

About the Companion Website

This book is accompanied by a companion website:

www.wiley.com/go/nichols/sedimentology3



This website includes:

- Figures from the book as PowerPoint slides

PART **A**



Sedimentary Materials, Processes and Products

The logical place to start in sedimentology is to consider the components of sediments and sedimentary rocks and the processes of transport and deposition. This provides the basis for building up an understanding how material accumulates in different sedimentary environments and how these deposits may then be interpreted in terms of processes and products.

The first part of this book covers the sedimentary components in two chapters, the first dealing with sands, muds and gravels, the clastic sedimentary material encountered in a wide variety of depositional environments on land and in the sea. All other sedimentary components are described in a separate chapter, including materials of biogenic origin which form limestones in marine settings, chemical precipitates that occur where evaporation takes place and sediments associated with volcanism.

In many ways, Chapter 4 is the most important in the book because it provides the basis for understanding how sedimentary deposits, modern and ancient, can be interpreted in terms of physical processes in air and in water. These processes result in sedimentary structures in rocks which provide important clues about the environment of deposition and help to build up an understanding of how environments have changed through time. The way that sediments and sedimentary rocks are described, how data is recorded and interpreted is covered in Chapter 5.

When using the information in these chapters as part of a taught course it can be useful to

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introduce some of it in the context of depositional settings in which it is most relevant. Examples might include:

- Covering the biogenic components described in Chapter 3 in the context of shallow marine environments where limestones form (Chapter 16).
- Describing the products of evaporation when considering ephemeral lakes (Chapter 10) or arid coastal settings (Chapter 16).
- Explaining how bedforms generate cross-bedding through description of aeolian processes and products (Chapter 8).
- Providing an explanation of wave processes in the context of perennial lakes (Chapter 10), deltas (Chapter 13) or coastal environments (Chapter 14).
- An explanation of turbidity currents and their deposits might best form part of a section on deep marine environments (Chapter 17).

The order in which the subject matter is covered throughout this book follows a logic that works in a written context, but when teaching or learning a different approach might be more appropriate. There is a good case to be made for the explanations of how sedimentary basins form and fill in the final chapter to come before all other topics – presenting the big picture of sedimentology and stratigraphy at the outset.

CHAPTER 1



Introduction to Sedimentology and Stratigraphy

Sedimentology is the study of the processes of formation, transport and deposition of material that accumulates as sediment in continental and marine environments and eventually forms sedimentary rocks. Stratigraphy is the study of rocks to determine the order and timing of events in Earth history: it provides the time frame that allows us to interpret sedimentary rocks in terms of dynamic evolving environments. The stratigraphic record of sedimentary rocks is the fundamental database for understanding the evolution of life, plate tectonics through time and global climate change.

CHAPTER OUTLINE

1.1 Overview
1.2 Sedimentology
1.3 Stratigraphy
1.4 Sedimentology and Stratigraphy
Further Reading

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1.1 Overview

Physical, chemical and biological processes act on the surface of the Earth all the time. Some of these surface processes change the nature and composition of the material and make it available for transport and deposition in a variety of different places on land and in the sea. Chemical and biological activity also generate materials that accumulate in some settings. In time these sediments may become sedimentary rocks buried in the subsurface or uplifted by tectonic activity into modern landscapes. The study of these processes and their products is the science of *sedimentology*.

Layers of sediments and sedimentary rocks are known as strata. *Stratigraphy* is a discipline which encompasses the relationships between stratal units, the relative and absolute ages of these strata and the whole framework of geological history. It is one of the oldest disciplines within the geological sciences and includes the use of fossils as indicators of different periods of Earth history. It includes the relationships between igneous bodies and metamorphic rocks as well as sedimentary strata.

The relationships between modern and ancient, sedimentology and stratigraphy, are illustrated in Figs. 1.1 and 1.2. A modern river is a place where a variety of sedimentary processes occur.

- A flow of water confined to a channel has sufficient energy to transport sand which is deposited on bars in the river and, in doing so, creates a sedimentary unit. These are physical processes of transport and deposition.
- When the river floods, water and sediment are carried on to the floodplain adjacent to the channel, where it provides nutrients for a community of plants and animals. Soils form by a mixture of physical, chemical and biological processes.

A sedimentological study of this modern river environment would involve looking at the patterns of sand deposition in the channel and on the bars in relation to the velocity and depth of the water flow. The grain size and extent of the deposits on the floodplain would be related to the magnitude and frequency of flood events. Flooding and the degree of waterlogging also play a role in determining the characteristics of the soils that form on the floodplain along with the climate in the area.



FIGURE 1.1 A modern depositional environment: a sandy river channel and vegetated floodplain.

The rocks exposed in the cutting (Fig. 1.2) can be described in terms of their sedimentological features

- The sandstone body is made up of grains whose size, shape and composition can be related to the river processes that deposited them. The base of the unit marks the surface where the channel cut into the sediment below, and the pattern and orientation of surfaces within the body can inform about depth, velocity and direction of flow in the channel.
- The layering in the beds below and above the sandstone body can be interpreted in terms of flooding events bringing fine sand and mud onto a floodplain. The extent of the layers provides an indication of the magnitude of the flooding events and features within the sand and mud are evidence of soil formation.



FIGURE 1.2 Sedimentary rocks interpreted as the deposits of a river channel (the lens of sandstones in the centre right of the view) scoured into mudstone deposited on a floodplain (the darker, thinly bedded strata below and to the side of the sandstone lens).

These rocks can be related to other rocks occurring in strata above or below, and a local stratigraphy can be established on the basis that the layers below are older than the layers above. Fossils within the beds can provide information of their relative age – although, as will be discussed in later sections, the deposits of rivers and floodplains are generally not rich in the remains of organisms – and the beds placed within a broader, global stratigraphic framework.

1.2 Sedimentology

'Sedimentology' has only existed as a distinct branch of the geological sciences for a few decades. It developed as the observational elements of physical stratigraphy became more quantitative, and the layers of strata were considered in terms of the processes which formed them. However, the concept of interpreting sedimentary rocks in terms of modern process – 'the present is the key to the past' – dates back to the 18th and 19th centuries. Assuming that the laws that govern physical and chemical processes have not changed through time, detailed measurements of sedimentary rocks can be used to make estimates (to varying degrees of accuracy) of the physical, chemical and biological conditions which existed at the time of sedimentation. These conditions may include, for example, the salinity, depth and flow velocity of water in a lake or sea, the strength and direction of the wind in a desert and the tidal range in a shallow marine setting.

A link can be made between modern environments of deposition and sedimentary rocks by interpreting the physical, chemical and biological characteristics of those rocks in terms of processes of formation. This is the basis on which it is possible to develop an understanding of what the Earth looked like at different times in different places during Earth history. The rocks in Fig. 1.3 are from the Cretaceous of the Isle of Wight in southern England: impressions of dinosaur footprints can be seen as bulbous shapes on the base of one bed and weather out of the cliff face as casts. The characteristics of the beds below and above indicate that deposition occurred on a river floodplain, perhaps similar to the setting shown in Fig. 1.1. The sedimentology of the rocks, therefore, informs us about the environment where these dinosaurs lived more than a hundred million years ago.

Every depositional environment has a unique combination of processes, and the



FIGURE 1.3 A cliff on the Isle of Wight in southern England exposes rocks that have been dated as Cretaceous in age. The sandstones and mudstones are interpreted as river channel and overbank deposits and the presence of the casts of Iguanodon footprints (inset) indicate that these dinosaurs lived in this fluvial environment over one hundred million years ago.

products of these processes, the sedimentary rocks, will be a similarly unique assemblage. For the convenience of description and interpretation, depositional environments are classified as, for example, a delta, an estuary or a shoreline, and sub-categories of each are established, such as wave-dominated, tide-dominated and river-dominated deltas. This approach is in general use by sedimentary geologists and is followed in this book.

It is, however, important to recognise that these environments of deposition are convenient categories or 'pigeonholes' and that the description of them tends to be of 'typical' examples. The reality is that every delta, for example, is different from its neighbour in space or time, that every deltaic deposit will also be unique, and although we categorise deltas into a number of types, our deposit is likely to fall somewhere in between these 'pigeonholes'. Sometimes it may not even be possible to conclusively distinguish between the deposits of different environments, especially if the data set is incomplete – which it inevitably is when dealing with events of the past. However, by objectively considering each bed in terms of physical, chemical and biological processes, it is always possible to provide an indication of how a sedimentary rock was formed.

1.3 Stratigraphy

Use of the term 'stratigraphy' dates back to d'Orbingy in 1852, but the concept of layers of rocks, or strata, representing a sequence of events in the past is much older. In 1667 Steno developed the principle of superposition: 'in a sequence of layered rocks, any layer is older than the layer next above it'. Stratigraphy can be considered as the relationship between rocks and time, and the stratigrapher is concerned with the observation, description and interpretation of direct and tangible evidence in rocks to determine the history of the Earth. We recognise that our planet is a dynamic place, where plate tectonics creates mountains and oceans and where changes in the atmosphere affect the climate, perhaps even on a human time scale. To understand how these global systems work, we need a record of their past behaviour to analyse, and this is provided by the study of stratigraphy.

Stratigraphy provides the temporal framework for geological sciences. The relative ages of rocks, and hence the events which are recorded in those rocks, can be determined by simple stratigraphic relationships (younger rocks generally lie on top of older, as Steno recognised), the fossils that are preserved in strata and by measurements of processes such as the radioactive decay of elements which allow us to date some rock units. At one level, stratigraphy is about establishing a nomenclature for rock units of all ages and correlating them all over the world, but at another level, it is about finding evidence for climate change in the past or the movements of tectonic plates. One of the powerful tools we have for predicting future climate change is the record in the rock strata of local and global changes over periods of thousands to millions of years. Furthermore, our understanding of evolutionary processes is in part derived from the study of fossils found in rocks of different ages that tell us about how forms of life have changed through time. Other aspects of stratigraphy provide tools for applied geosciences: for example, 'sequence stratigraphy' is a predictive technique, widely used for the exploration of the subsurface for energy and mineral resources.

1.4 Sedimentology and Stratigraphy

The relationship between these two closely related geoscience disciplines is illustrated in Fig. 1.4. The interpretation of both sediments in modern environments and sedimentary rocks in terms of processes and the associations of them that characterise environments of deposition provides the basis for further studies. These studies may include the consideration of successions in sedimentary basins and the transition from a sedimentological to a stratigraphic analysis as a temporal framework of geologic time is introduced.

The combination of sedimentology and stratigraphy allows us to build up pictures of the Earth's surface at different times in different places and relate them to each other. The character of the sedimentary rocks deposited might, for example, indicate that at one time, a certain area was an arid landscape, with desert dunes, with washes of gravel coming from a nearby mountain range. In that same place, but at a later time, conditions allowed the formation

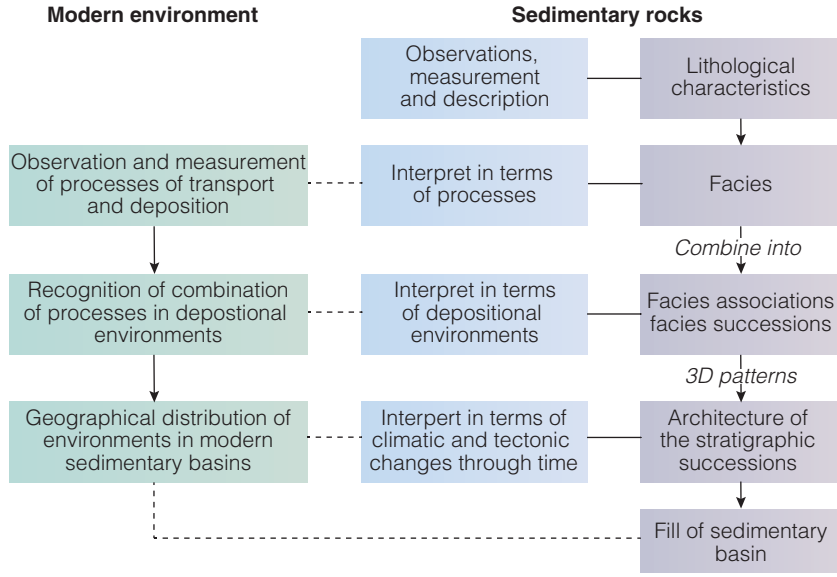

FIGURE 1.4 The relationships between observations and interpretations in modern environments and successions of sedimentary rocks. The procedures for defining facies and facies associations are covered in Chapter 5 and the context of sedimentary basins in Chapter 25.

of coral reefs in a shallow sea far away from any landmass, and we can find the record of this change by interpreting the rocks in terms of their processes and environments of deposition. Furthermore, we might establish that at the same time as there were shallow tropical seas in one place, there lay a deep ocean a few tens of kilometres away where fine sediment was deposited by ocean currents. We can thus build up pictures of the *palaeogeography*, the appearance of a region during some time in the past and establish changes in palaeogeography through Earth history. To complete the picture, the distribution of different environments and their changes through time can be related to plate tectonics, because mountain building provides the source for much of the sediment, and plate movements also create the sedimentary basins where sediment accumulates.

Sedimentology and stratigraphy cannot be considered in isolation of other aspects of geology, and in particular, plate tectonics, petrology, palaeontology and geomorphology are complementary topics. Reference is made to these subjects in the text, but only a basic knowledge of these topics is assumed.

Further Reading

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CHAPTER 2



Clastic Sediments: Gravel, Sand and Mud

Clastic sediments and sedimentary rocks are composed of fragments which result from the weathering and erosion of older rocks. They are classified according to the sizes of clasts present and the composition of the material. Analysis of gravels and conglomerates can be carried out in the field and can reveal where the material came from and how it was transported. Sands and sandstones can also be described in the field, but for a complete analysis examination under a petrographic microscope is required to reveal the composition of individual grains and their relationships to each other. The finest sediments, silt and clay, can only be fully analysed using scanning electron microscopes and X-ray diffractometers. The proportions of different clast sizes and the textures of terrigenous clastic sediments and sedimentary rocks can provide information about the history of transport of the material and the environment of deposition.

CHAPTER OUTLINE

2.1 Classification of Sediments and Sedimentary Rocks
- **2.1.1** Clastic Sediments and Sedimentary Rocks
- **2.1.2** The Udden-Wentworth Grain Size Scale

2.2 Gravel and Conglomerate
- **2.2.1** Composition of Gravel and Conglomerate
- **2.2.2** Texture of Conglomerate
- **2.2.3** Shapes of Clasts

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2.3 Sand and Sandstone
- **2.3.1** Grain Types in Sands and Sandstones
- **2.3.2** Sandstone Nomenclature and Classification
- **2.3.3** Petrographic Analysis of Sandstones
- **2.3.4** Thin Section Analysis of Sandstones
- **2.3.5** Matrix and Cement
- **2.3.6** Practical Thin Section Microscopy

2.4 Clay, Silt and Mudrock
- **2.4.1** Definitions of Terms in Mudrocks
- **2.4.2** Silt and Siltstone
- **2.4.3** Clay Minerals
- **2.4.4** Petrographic Analysis of Clay Minerals
- **2.4.5** Clay Particle Properties

2.5 Textures and Analysis of Clastic Sedimentary Rocks
- **2.5.1** Granulometric and Clast Shape Analysis
- **2.5.2** Clast Shape Analysis
- **2.5.3** Maturity of Clastic Material
- **2.5.4** Cycles of Sedimentation

2.6 Clastic Sediments: Summary
Further Reading

2.1 Classification of Sediments and Sedimentary Rocks

A convenient division of all sedimentary rocks is shown in Fig. 2.1. Like most classification schemes of natural processes and products, it includes anomalies (a deposit of chemically precipitated calcium carbonate would be classified as limestone, not an evaporite) and arbitrary divisions (the definition of limestone as a rock having more than 50% calcium carbonate), but it serves as a general framework.

- *Clastic material* is made up of particles or *clasts* that are principally detritus eroded from bedrock and are commonly made up largely of silicate minerals. This material may also be referred to as *terrigenous clastic* sediment, *siliciclastic sediments* or *detrital sediments* although it may not be exclusively from land (terrigenous), non-silicate material can be included and some clasts may not be detritus (see below). Clasts range in size from clay particles measured in microns, to boulders metres across. Sandstones and conglomerates make up 20–25% of the sedimentary rocks in the stratigraphic record and mudrocks are 60% of the total.

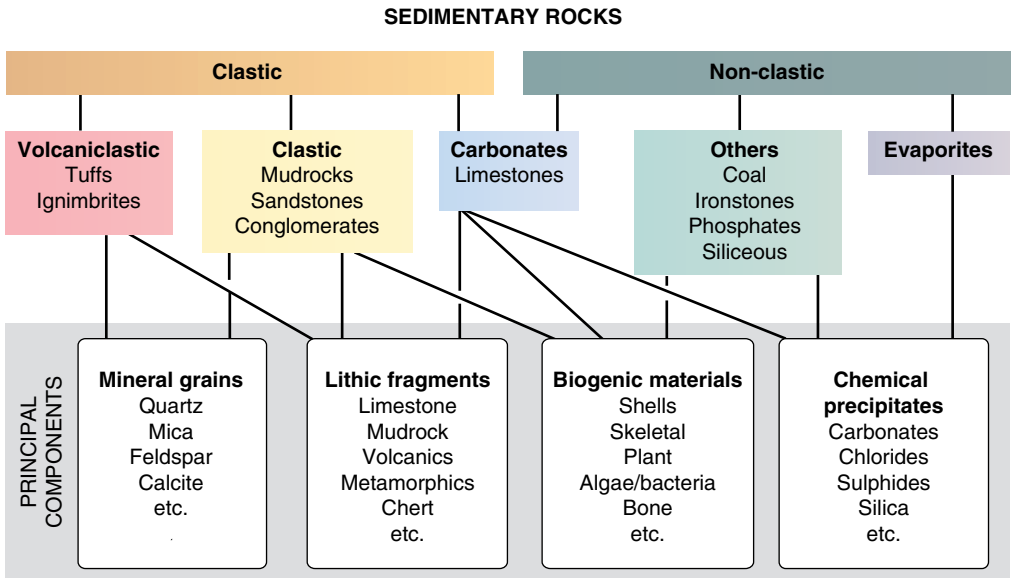

FIGURE 2.1 A classification scheme for sediments and sedimentary rocks.

- *Carbonates:* by definition, limestone is any sedimentary rock containing over 50% calcium carbonate ($CaCO_3$). In the natural environment, a principal source of calcium carbonate is from the hard parts of organisms, mainly invertebrates such as molluscs. Limestones constitute 10–15% of the sedimentary rocks in the stratigraphic record.
- *Evaporites* are deposits formed by the precipitation of salts out of water due to evaporation.
- *Volcaniclastic sediments* are the products of volcanic eruptions or the result of the breakdown of volcanic rocks.
- Other sediments and sedimentary rocks are sedimentary ironstone, phosphate sediments, organic deposits (coals and oil shales) and cherts (siliceous sedimentary rocks). These are volumetrically less common than the above, making up about 5% of the stratigraphic record, but some are of considerable economic importance.

In this chapter, clastic deposits are considered: the other types of sediment and sedimentary rock are covered in Chapter 3.

2.1.1 Clastic Sediments and Sedimentary Rocks

A distinction can be drawn between sediments (generally loose material) and sedimentary rocks, which are lithified sediment: *lithification* is the process of 'turning into rock' (*19.1*). Mud, silt and sand are all loose *aggregates*; the addition of the suffix '-stone' (mudstone, siltstone, sandstone) indicates that the material has been lithified and is now a solid rock. Coarser, loose gravel material is named according to its size as granule, pebble, cobble and boulder aggregates which become lithified into conglomerate (sometimes with the size range added as a prefix, e.g. 'pebble conglomerate').

A three-fold division on the basis of grain size is used as the starting point to classify and name terrigenous clastic sediments and sedimentary rocks: gravel and conglomerate consist of clasts greater than 2 mm in diameter; sand-sized grains are between 2 and 1/16 mm (63 µm/microns) across; mud (including clay and silt) is made up of particles less than 63 µm in diameter. There are variants on this scheme and there are a number of ways of providing subdivisions within these categories, but sedimentologists generally use the Wentworth Scale (Fig. 2.2) to define and name terrigenous clastic deposits.

2.1.2 The Udden-Wentworth Grain Size Scale

Known generally as the *'Wentworth Scale'*, this is the scheme in most widespread use for the classification of aggregates of particulate matter (Fig. 2.2). The divisions on the scale are made on the basis of factors of two: for example, medium sand grains are 0.25 to 0.5 mm in diameter, coarse sand grains are 0.5 to 1.0 mm, very coarse sand 1.0 to 2.0 mm and so on. It is therefore a logarithmic progression, but a logarithm to the 'base two', as opposed to the 'base ten' of the more common 'log' scales. This scale has been chosen because these divisions appear to reflect the natural distribution of sedimentary particles and in a simple way, it can be related to starting with a large block and repeatedly breaking it into two pieces.

Four basic divisions are recognised:

- clay (<4 µm),
- silt (4–63 µm),
- sand (63 µm or 0.063 to 2.0 mm), and
- gravel/aggregates (>2.0 mm).

The *phi scale* is a numerical representation of the Wentworth Scale. The Greek letter 'Ø' (phi) is often used as the units for this scale. Using the logarithm base two, the grain size can be denoted on the phi scale as

$$Ø = -\log_2(\text{grain diameter in mm})$$

The negative is used because it is conventional to represent grain sizes on a graph as decreasing from left to right *(2.5.1)*. Using this formula, a grain diameter of 1 mm is 0Ø: increasing the grain size, 2 mm is −1Ø, 4 mm is −2Ø and so on; decreasing the grain size, 0.5 mm is +1Ø, 0.25 mm is 2Ø and so on.

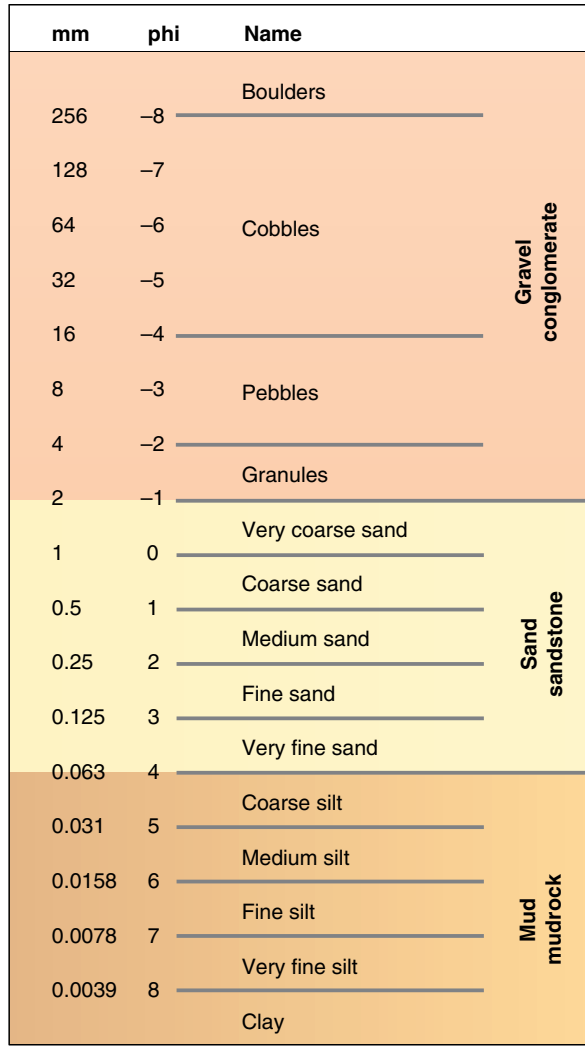

FIGURE 2.2 The Udden-Wentworth grain-size scale for clastic sediments: the clast diameter in millimetres is used to define the different sizes on the scale, and the phi values are $-\log_2$ of the grain diameter.

2.2 Gravel and Conglomerate

Clasts over 2 mm in diameter are divided into granules, pebbles, cobbles and boulders (Fig. 2.2). Consolidated gravel is called *conglomerate* (Fig. 2.3) and, when described, will normally be named according to the dominant clast size: for example, if most of the clasts are between 64 and 256 mm in diameter the rock would be called a cobble conglomerate. The term *breccia* is commonly used for conglomerate made up of clasts that are angular in shape (Fig. 2.4). In some circumstances, it is prudent to specify that a deposit is a 'sedimentary breccia' to distinguish it from a 'tectonic breccia' formed by the fragmentation of rock in fault zones. Mixtures of rounded and angular clasts are sometimes termed *breccio-conglomerate*. The noun *rudite* and the adjective *rudaceous* are also sometimes used for limestones *(3.1)*.

2.2.1 Composition of Gravel and Conglomerate

A more complete description of the nature of gravel or conglomerate can be provided by considering the types of clast present. If all the clasts are of the same material (all of granite, for example), the conglomerate is considered to be *monomict* (Fig. 2.5). A *polymict* conglomerate