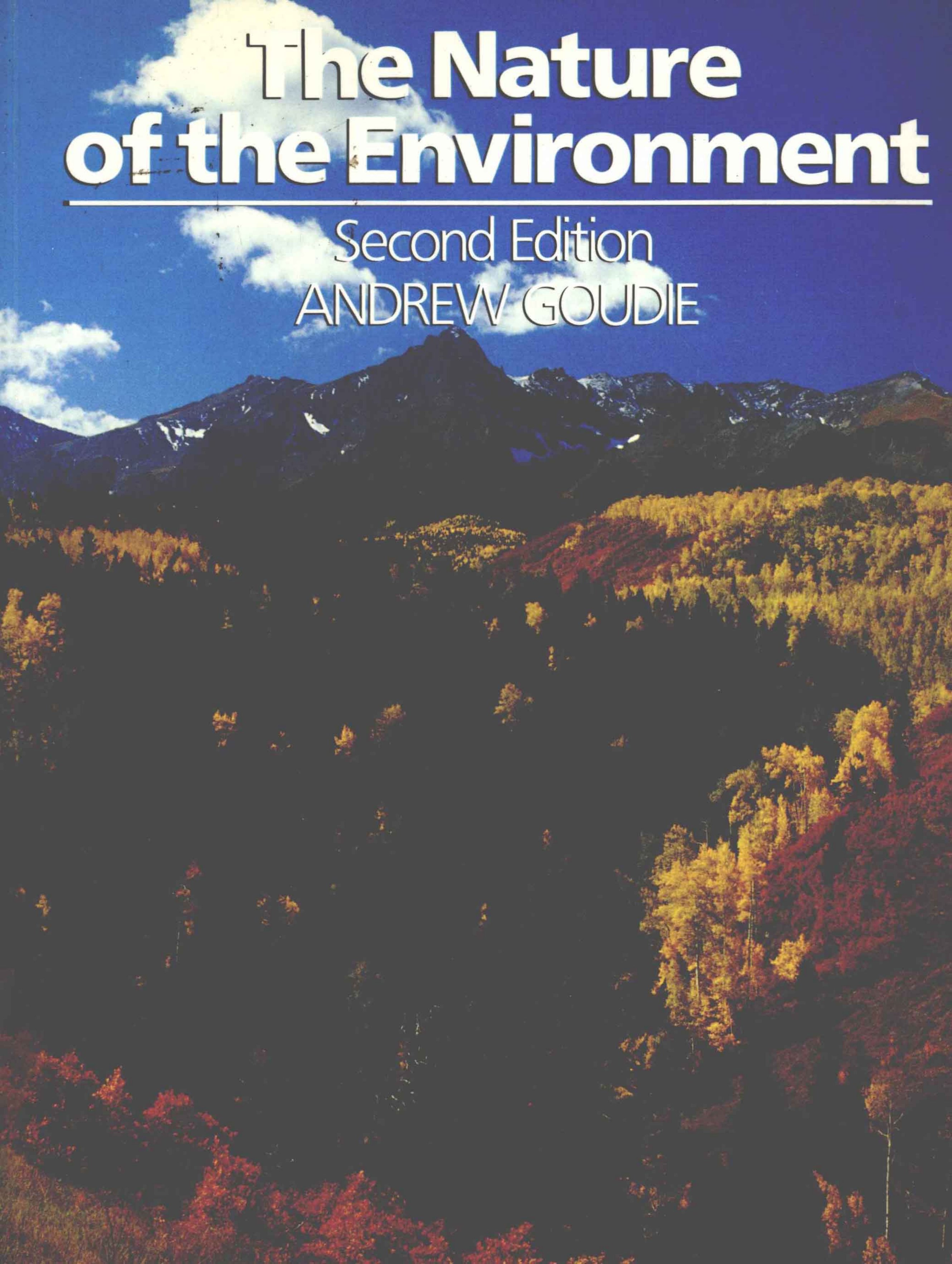
The Nature of the Environment

Second Edition

ANDREW GOUDIE



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Frontispiece A montane forest ecosystem on the slopes of a volcano in the Mount Bosavi National Park, Papua New Guinea.

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The Nature of the Environment

Preface

First Edition

The content of courses in physical geography has changed markedly in recent years for three main reasons. First, there has been a desire to make physical geography more relevant to human affairs, to integrate it more closely with human geography, to become more concerned with natural hazards, to investigate environmental problems and to assess the human impact on environment change. Second, geography as a whole has become involved with process, measurement and numerical analysis. Third and most important, near-revolutionary developments have taken place in the subject matter of physical geography – notably in ecology, hydrology, plate tectonics and our knowledge of the Pleistocene.

All these changes mean that many general textbooks in physical geography are ceasing to have the utility they once had, and new books are needed. This book is intended as such a contribution.

In chapters 1 and 2 we cover developments in such matters as plate tectonics and climatic change, as well as background information on global patterns of natural phenomena. One aim of the book is to stress the way in which the components of the environment are integrated at different scales. Accordingly, the next four chapters deal with the four main world zones (polar, mid-latitude, desert and tropical), describing their features, showing how the different components of the environment are interrelated and explaining their problems, hazards and some of the modifications wrought by man. Part III deals with two rather special environments that occur in any one of the four main zones – mountains and coasts – but the same approach is followed as in the previous four chapters. Part IV moves from major environments to a consideration of some major classes of phenomena (e.g. rivers), and once again interrelationships are explored and human implications assessed.

The overall purpose of the book, therefore, is to impart modern information on the human environment at various scales from the global to the local; to integrate the study of geomorphology, climatology, hydrology, pedology and biogeography; and to consider the ways in which we ourselves both mould and are moulded by our landscape and environment. It is hoped that this approach will encourage readers to move on to books covering aspects of landscape and environment and their relationships to plants, animals and mankind in greater depth and detail than space allows here. To that end, I have included a guide to further reading.

To avoid the disturbance that results when the text is broken up by detailed referencing, I have refrained from providing such documentation. This means that I cannot give the acknowledgement I would like to the work and ideas of other authors, to whom I am greatly in debt.

I am grateful to those publishers and authors who have allowed me to reproduce figures published elsewhere, and to the following for comments on earlier drafts: Dr M. A. Summerfield (now of the University of Edinburgh); Professor S. Gregory; Professor E. Derbyshire; David Wright; Dr B. J. Knapp; Eleanor M. Rawling; David F. Horsfall; Gordon Smith and Dr Heather Viles.

November 1983

Second Edition

For this second edition, I have expanded sections deserving greater coverage, improved some of the plates and figures, updated the Guide to Further Reading and added material of topical interest (e.g., the threat of worldwide sea-level rise, the ozone crisis, El Niño, etc.). In an attempt to make the book even more valuable for student use, questions and exercises have been added, and I am grateful to Dr Nick Middleton and Mr Mike Corbett for assistance in preparing them.

A.S.G.
August 1988

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Contents

PART I

The Global Framework

1 Global Geological Background

1.1 The ancient earth

Our solar system consists of planets such as the earth, moons, asteroids, comets, meteorites, dust and gas – and a central star – the sun. We do not know exactly how the solar system formed, though the most favoured theory is that condensation took place from a great revolving gas cloud in space, which gradually contracted under gravity. This made the central mass hot enough for thermonuclear reactions to set in, and so a new star was formed – the sun.

Although we may not be sure *how* the solar system originated, we are rather more certain about *when* it originated. Dates for the oldest earth rocks, the oldest moon rocks and some stony meteorites all suggest that the solar system is about 4600 million years old. This is an almost inconceivable time span, especially when we think that our own species has inhabited the earth for only a minute fraction of that time – probably around 2–3 million years.

The world we know today thus has an enormous and complicated history, and to understand the present configuration of the major elements of our planet – the oceans and the continents – we need to look at this history.

1.2 Core, mantle and crust

When it first formed, the earth must have been a molten mass. As it gradually cooled it became differentiated into a series of concentric layers. In the interior of the earth (figure 1.1) we have a layer called the *core*, the outer parts of which have the properties of a liquid and the inner parts of which have the properties of a solid. We know that it is very dense, and that it is probably composed largely of iron, with lesser amounts of other elements such as nickel. We also know that

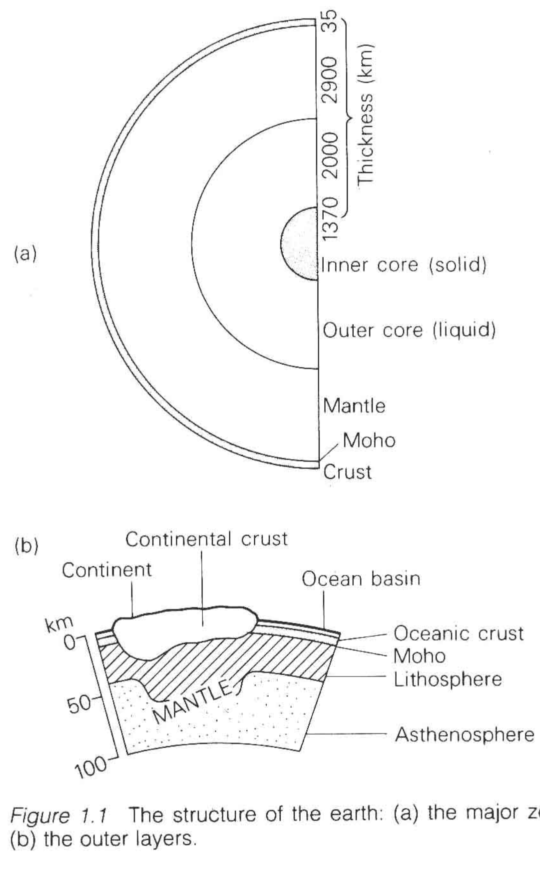

Figure 1.1 The structure of the earth: (a) the major zones (b) the outer layers.

Opposite The weathering and erosion of closely bedded sedimentary rocks has produced the distinctive 'pancake rock' formations on the west coast of the South Island of New Zealand.

it has very high temperatures – probably of the order of 5500°C – and very high pressures.

The middle layer of the earth is called the *mantle*. This is a thick layer (*c*.2800 km) composed of material in the solid state. It consists of 'heavy rock' including peridotite (composed largely of the silicate minerals olivine and pyroxene), dunite (pure olivine) and eclogite (a dense form of basalt). Temperatures within the mantle range from 5000°C near the core to 1300°C just below the crust. There are two main parts of the mantle. One part is so hot that is semi-molten and deformable; this is called the *asthenosphere*. It is overlain by a more rigid layer called the *lithosphere*.

The outer layer of the earth, called the *crust*, is very much thinner, generally being between 6 and 70 km thick, and is very much less dense than the underlying mantle, from which it has been derived by complex processes operating over many millions of years. The surface of separation between crust and mantle is called the *Mohorovičić Discontinuity* (after a Yugoslavian seismologist), but is often simplified to *Moho*. The crust occurs as two types: continental and oceanic. The continental crust (known as *sial*) is not very dense (averaging 2.7 gm cm^{-3} compared with 3.0–3.3 for oceanic crust and 3.4 for the upper mantle), but it tends to be relatively thicker (averaging 35–40 km, and reaching 60–70 km under high mountain chains) than the oceanic crust (called *sima*), which for its part averages only about 5–6 km in thickness. The continental crust has a varied and complicated composition, though it tends to be granitic above and basaltic beneath. The crust of the ocean basins consists simply of basaltic rocks – the granite is absent.

One particularly fascinating and important discovery of recent years has been that the ocean floors (and underlying oceanic crust) are relatively young. Some parts of the continental crust in Greenland and southern Africa are older than 3500 million years, whereas the oceanic crust is nowhere older than 250 million years.

1.3 The nature of the ocean floors

Viewed from space, one of the most striking features of the earth is how large a proportion of it is covered by the waters of the oceans. Only about 29 per cent of the earth's surface is composed of dry land – the rest is ocean. If we could remove all the water from the ocean basins some other remarkable facts would be revealed: first, the ocean floors are extremely complicated in their relief; second, that relief is characterised by some extraordinary mountains and enormous valleys or trenches.

Seaward from the coast there is generally a gently sloping platform that is called the *continental shelf* (figure 1.2), with a water depth of no more than about 180 m. In some parts of the world this shelf is very extensive, notably off China, Canada, northern Australia and western Europe (figure 1.3). Elsewhere, for example off the western coast of South America, it is very narrow, and deep water is reached very quickly as one moves off shore. The seaward edge of the

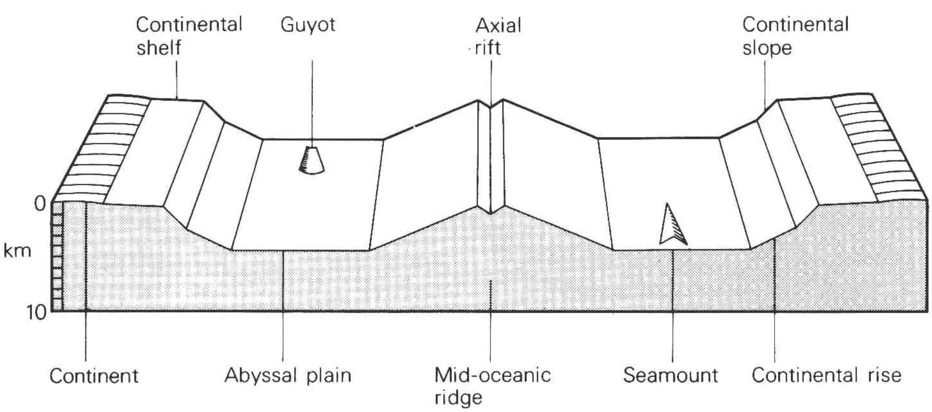

Figure 1.2 A diagrammatic cross-section illustrating some of the main features of the geomorphology of the oceans.