THE MAKING OF THE EARTH

Edited by
RICHARD FIFIELD

A newscientist GUIDE

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Basil Blackwell & New Scientist

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Foreword

In November 1956 a small and enthusiastic team of journalists and scientists launched *New Scientist*. Ever since then, with a few interruptions, *New Scientist* has provided a weekly dose of news from the world of science and technology.

Over the years, the magazine has reported research as it happened. Sometimes the findings that we described turned out to be less enduring than their discoverers first thought. Sometimes they went on to win Nobel prizes for the scientists involved. Theories that first provoked severe scepticism became established wisdom. Established wisdom was cast aside.

These guides bring together that 'history in the making'. In these pages you will find more than a scientific account of a particular subject. You will find the personalities and the problems; the excitement of discovery and the disappointment of wrong turnings and the frustration of delays. I hope, too, that you will find something of the excitement that scientists feel as they push back the frontiers of knowledge.

Science writing does not stand still any more than does science. So the past quarter of a century has seen changes in the way in which *New Scientist* has presented its message. You will find those changes reflected here. Thus this guide is more than a collection of articles carefully plucked from the many millions of words that have appeared over the years. It is a record of science in action.

Michael Kenward
Editor, New Scientist

Preface

The eminent physicist P. M. S. Blackett commented in a lecture to the Royal Institution of Great Britain, on Friday 23 March, 1956, that "Clegg, Almond and Stubbs were the first to prove definitely by this means [fossil magnetism] the movement of land masses relative to the poles".

This seemingly unimportant statement marked a high point in one of the most significant developments in the Earth sciences. The scientific revolution of which fossil magnetism is a part has roots that go back to the early decades of the 20th century, and some even older ones. The suggestion that the continents had split apart from each other in geological history had been around for some centuries, but the claim that the continents were not fixed but could wander about seemed altogether too bizarre even to many open-minded geologists in the early decades of the 20th century. Like all scientific revolutions, much of the scientific establishment was against "continental drift" because no one could explain what caused it.

At the beginning of the 17th century, the English essayist and philospher Francis Bacon had noticed that the outline of the eastern side of the Americas and the western side of Africa looked so similar that it seemed possible that they were once joined together. With the new sense of exploration and adventure in the centuries that followed, and especially as means of travel and communication improved, news filtered back of huge coal deposits on the European and American shores of the Atlantic. The geologists were quick to notice that the fossil plants that turned up in the American and European coals were often of the same species.

In 1859, the American geologist Antonio Snider-Pellegrini wrote a book which he ambitiously entitled *La Création et ses*

Mystères dévoilés. He included in his book two maps which he claimed showed the alteration of the relative positions of land and water since the creation. Snider believed in the Noachian deluge. He supposed the Earth once to have consisted of a continuous block, or mass, rising from the ocean, and that the mighty Atlantic Ocean had formerly been dry land. The two continents were formed by the division of the former block, and he believed the coals had formed from the materials washed from the continents as they divided.

A new enthusiasm for the idea that the continents had moved laterally came in the writings of the American geologist F. B. Taylor (in 1910) and the German meteorologist Alfred Wegener (in 1912). Wegener saw the similarity of the fit of the coastlines of Brazil and Africa as providing the "starting point of a new conception of the nature of the Earth's crust and of the movements occurring therein; this new idea is called the theory of the displacement of continents, or, more shortly, the displacement theory, since its most prominent feature is the assumption of great horizontal drifting movements which the continental blocks underwent in the course of geological time, and which presumably continue even today".

Within the past 25 years a new theory has revolutionised our understanding of the Earth's crust and the formation of the continents. The theory argues that the Earth's surface is made up of some 15 quite rigid "plates" in continuous motion relative to each other. Where they are moving apart in mid-ocean, ridges form. Where they converge, one plunges down into the mantle beneath, and ocean trenches are formed. Where an ocean plate meets continental crust, mountain ranges tend to be formed, as with the Andes. The interaction between the edges of the plates accounts for almost all earthquake activity. This theory sees the ocean beds as being continuously transformed. They are relatively recent compared with the rocks that constitute the basements of the great landmasses. The importance of the theory of "plate tectonics", as it has come to be known, is that it offers not only a physical basis for the ideas of continental drift, but that it provides a verifiable theory about the nature and history of the Earth's surface and of its inner regions.

Professor Blackett's discourse in 1956 was significant not just because an eminent physicist publicly gave credit to his colleagues and their ideas, but because it showed how valuable it is that scientists from various disciplines should work on a major topic.

Geophysics, of which fossil magnetism ("palaeomagnetism") had become a part, was in the years ahead to provide new ways of viewing and investigating our planet.

The Soviet Union launched the first man-made Earth satellite, Sputnik, on 4 October, 1957. The achievements of that satellite would contribute to the successes of the International Geophysical Years, for which plans had been drawn up in 1956. The IGYs were to become the most significant international cooperative venture in science. In turn, the IGYs would spawn the Antarctic Treaty and greatly enhance professional and public interest in "spaceship Earth". Sputniks became regular features of the night skies.

New Scientist was launched on 22 November, 1956, for a public eager for scientific information.

The new science journal and its readership were fortunate in that Peter Stubbs, one of the colleagues to whom Blackett referred in his RI lecture, was enticed away from his research to explain just what geophysics was all about. Soon, Stubbs joined the editorial staff of *New Scientist*, thus putting the journal in a unique position – unique for what was considered by its proprietors to be a newspaper of science and technology. Stubbs was to become not only one of the journal's most eminent physical science editors but also later its deputy editor.

Peter Stubbs had a considerable flair for communicating science and he had an enviable style of writing. He remained with *New Scientist* for over 20 years. That period saw the victory of the revolution in the Earth sciences against the establishment diehards, and it also saw the realisation of the implications of the revolution and the first harvest of fruits. *New Scientist* was able to chronicle the developments of the revolution leading to the testifiable theory of plate tectonics. As Professor Tuzo Wilson explains in his introduction (an article that he wrote to celebrate the journal's 25th anniversary): "As befits a mighty subject, it has needed many Lilliputians to assemble our fascinating picture of a mobile Earth."

Many strands of the complex story of the Earth's history have been successfully untied, but a multitude of knots have yet to be untangled. Even so, as Professor Preston Cloud emphasises in his chapter, we have enough threads to weave "a strong, if coarse-textured, tapestry of events". This book offers a view of that tapestry as presented in the pages of *New Scientist*.

For convenience, I have organised my selection of articles and news pieces into four parts.

The first part is concerned to set the clock back, and to look at some of the detective work that was required to unravel aspects of the Earth's long history, to consider how the planet might have been formed, and how it gained an atmosphere that could support life.

In the second part, I have included articles that provide support to the theories of continental drift, sea-floor spreading, and the concomitant theory of plate tectonics.

Part three looks at some of the insights that emerge if we accept the idea that the oceans and continents are carried on mobile, lithospheric plates that sometimes collide and override each other.

The final part hints at some of the pay-offs that have come from various geophysical techniques developed over the past few decades and from our understanding of plate tectonics. That final section also indicates some of the things that we can expect to emerge from our new-found ability to look back at planet Earth from space.

This compilation would not have been possible without the painstaking and dedicated work of *New Scientist*'s book researcher, Jane Moore. She compiled a list of the journal's entire coverage of the Earth sciences, for which I am sincerely grateful. I would also like to thank Karen Iddon, my secretary, for her assistance and patience which enabled me to complete my task of producing a final manuscript. As always, Neil Hyslop shouldered the task of preparing the original line drawings.

Richard Fifield

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PART ONE
Introduction

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Geology: a historical perspective

RICHARD FIFIELD

Early interest in the Earth and its rocks can be traced back to the ancient Greeks, including Herodotus, Pythagoras and Strabo. The Roman Seneco and the Chinese Zhang Heng were both interested in the causes of earthquakes, and Heng (AD 78–139) invented the first seismograph with which to record an earthquake. Avicenna (980–1037), the Persian physician and philosopher, became the father of the Earth sciences in the Arab world. After the Renaissance, Leonardo da Vinci (1452–1519) correctly explained that fossils were remains of former living creatures. Georg Agricola (1494–1555) did much to rationalise aspects of metalliferous mining with his *De re Metallica*, published in Basle in 1556.

The strict application of the Old Testament dominated thinking from the 16th through to the middle of the 19th century, with beliefs in the Biblical Flood of Noah's time causing denudation, and subsequent erosion, earthquakes and volcanoes responsible for decay. Bishop James Ussher (1581–1656) calculated from the Old Testament that the Earth was created in the year 4004 BC. The French naturalist Comte Georges Buffon (1707–88) deduced that the age of the Earth must run to millions of years. Scotsman James Hutton (1726–97) argued that the Earth's antiquity was unfathomable: "we find no vestige of a beginning, no prospect of an end".

Hutton became the founder of "modern geology". He developed theories about Earth processes. He accepted the idea of denudation and considered the topography of the continents to be sculptured by rain and river action. Hutton explained concepts of sedimentation and lithification, and the formation of strata. He claimed that from time to time rocks were raised from