PREFACE

In the summer of 1977, the Voyager 1 and Voyager 2 space probes were launched, on a mission to explore the deep space beyond our Solar System. Interestingly, each probe carried a "Golden Record", a gold disc containing audio-visual information, including photos of the Earth's landscape and life forms, spoken greetings in 55 different languages, sounds of the Earth, and a collection of indigenous, classical, and contemporary music. It was hoped that if the probes ever achieved contact with intelligent beings, this information would help to build a picture of the planet from which these probes originated.

Now, more than 40 years have passed since the launch of the Voyager probes, and many other efforts to detect intelligent aliens or Earth-like planets have been launched. However, no other alien life has been identified to date, and although a few potentially habitable planets have been discovered in other star systems and galaxies, none of them are exactly like our Earth. Even as we look beyond our own Solar System and Milky Way Galaxy, there is one thought we should always bear in mind: our beautiful Earth is quite unique, and our current presence may be a rare occurrence in the history of the cosmos.

This textbook seeks to tell the story of our Earth and the great natural forces that continue to shape it from within and without. The textbook also explores what we know about the space and celestial objects surrounding us. Each chapter begins with a simple summary and a list of learning objectives, and the text is accompanied by many stunning images and informative charts, to help you gain a better understanding of complicated concepts and terms. After completing this textbook, you can expect to develop a strong understanding of key principles and concepts in Earth science, astronomy, and space exploration, and it is hoped that you will also develop a stronger appreciation of our beautiful Earth.

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CHAPTER 1 OUR BEAUTIFUL EARTH

In this chapter, you will learn about how the Earth was formed, as well as its compositional spheres and geological history. After studying this chapter, you will be able to:

-- Describe the formation process of the Earth

-- Describe in order the main spheres that make up the Earth

-- Describe major events that occurred in the geological history of the Earth

Figure 1-1-1. An artist's conception of the birth of a star and its planets. Image courtesy of NASA.

1-1 The Formation of the Earth

Picture a giant cloud of dust and gas drifting aimlessly through space. A powerful external force, such as that caused by the explosion of a star, disturbs this cloud and induces it to start spinning. This spinning effect creates heat and gravitational force, causing the cloud to collapse into a giant spinning disk with an extremely dense and hot center (Figure 1-1-1). This disk is known as a protoplanetary disk, the centre of which eventually coalesces into a star, while the outer leftover material aggregates to form planets and other celestial objects. Our Solar System was formed in this way about 4.6 billion years ago, based on dating of meteorites, asteroids, and the oldest Earth rocks, and similar dating suggests the Earth came into being about 4.54 billion years ago.

The early Earth was a fiery ball of molten material, heated by gravitational forces, radioactive decay, and collisions with other meteorites and celestial objects. One such collision is believed to have flung some of the Earth's material into space, and this material eventually condensed to form the Moon. As the Earth slowly stabilized and cooled, heavier elements settled inward to form a metallic core, while lighter material drifted outward to form a layer of molten rock termed the mantle, which completely envelops the core. The exterior of the mantle eventually cooled to form the solid crust, and this is the layer where all known living organisms exist. This formation process gave rise to the layered structure of the Earth (Figure 1-1-2), and further provided the foundation for the development of Earth's magnetic field, without which life on Earth could not have emerged.

Chapter 1 Cover Image. Asia from space, with night lights in the background. Image courtesy of NASA.

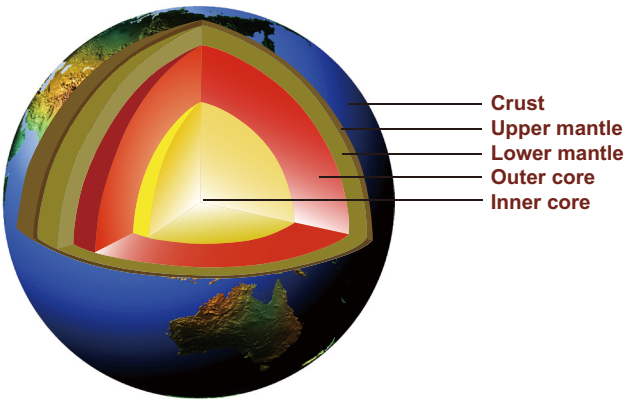

Figure 1-1-2. Schematic depicting the layered structure of the Earth, including the core (inner & outer core), mantle (lower & upper mantle), and the crust, drawn to their actual proportions.

1-2 The Spheres of the Earth

The Earth is not a perfect sphere, but is slightly flattened at the poles and swollen at the Equator. The Earth has an average diameter of about 12,742 kilometres (km), but this increases to 12,756 km at the Equator and decreases to 12,713 km at the poles, a difference of about 43 km.

Despite this, we can still view the Earth as a planet made up of spheres, due to the layered structure created by its formation process (Figure 1-2-1). The interior of the Earth consists of the core, which can be divided between an inner core with a radius of about 1,250 km and an outer core of about 2,200 km in thickness. The boundary of the inner core and outer core is known as the Lehmann-Bullen Discontinuity, as it was independently discovered in 1936 by the Danish seismologist Inge Lehmann (1888-1993) and the New Zealand geologist Keith Edward Bullen (1906-1976). The mantle can also be divided into the lower mantle (about 2,550 km thick) and the upper mantle (about 250 km thick), and the boundary in between is known as the Gutenberg Discontinuity, after the German-American geologist Beno Gutenberg (1889-1960). The crust ranges from 5-100 km in thickness, with continental crust being thicker and less dense than oceanic crust. The boundary zone between the crust and the mantle is known as the Mohorovičić Discontinuity, after the Croatian geologist Andrija Mohorovičić (1857-1936).

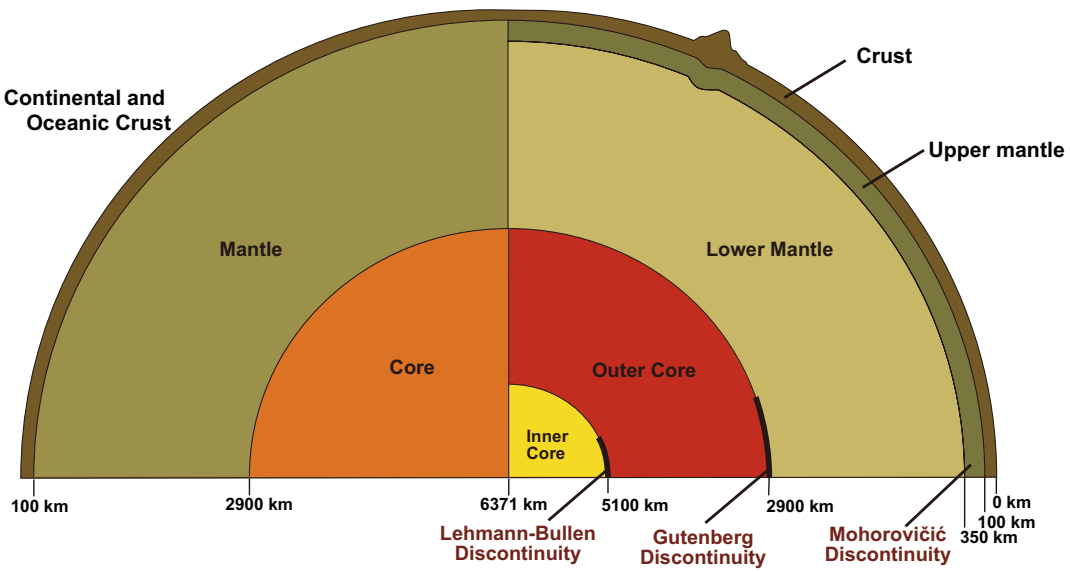

Figure 1-2-1. Schematic depicting the spherical layers of the Earth, with their approximate thickness.