1. Introduction

The topics covered in this book are designed to give you a basis for understanding the processes and properties of the Earth's interior so that you can answer these questions (and many others) for yourself. The book is designed for those with no previous exposure to the geological sciences. In fact, the only prerequisite is a willingness to consider new ideas, weigh the evidence, and draw conclusions.

A typical and normal way of understanding new things is to compare them to your own set of experiences and observations, and then to decide if they make sense, and see if they raise any questions which you can attempt to answer by some experiment or measurement (this is science!). However, to fully appreciate the processes which occur in the Earth's interior, you will have to expand your perspective, and consider scales of processes which are outside of your realm of experience.

For example, in this books, we will consider:

Time scales

- 0-1 sec: earthquakes, volcanic eruptions, other catastrophes
- 4.5 Billion years (140,000,000,000,000,000 sec): Age of the Earth
- 15 Billion years (470,000,000,000,000,000 sec): Age of the Universe

Speeds
• plate motions: 2.5 cm/yr (0.0000000018 mph)
• earthquakes and volcanos: 1 m/s (2.2 mph)
• seismic waves: 6 km/s (13,416 mph)
• speed of light: 300,000 km/s (669,600,000 mph)

Pressures
• 0-1 atmosphere: surface and out into space
• 3,650,000 atmospheres: center of the Earth

Temperatures
• absolute zero (-273°C): deep space
• 0-100°C: our experience
• 3,300°C: center of the Earth
• 2,000,000,000°C: center of a Red Giant star

Extra Info: When you see an inset like this, it contains information that may not be necessary for your understanding of the concept, but may provide further context or more technical background.

Earth Calendar - To put the time scales in perspective, consider an “Earth Calendar” in which midnight, January 1, represents the formation of the Earth, and the following midnight, December 31, is the present. Therefore, the entire history of the Earth is displayed as a single "calendar year".

<table>
<thead>
<tr>
<th>Event</th>
<th>Age</th>
<th>Calendar date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Earth formed</td>
<td>4,550</td>
<td>Jan. 1</td>
</tr>
<tr>
<td>Oldest rocks</td>
<td>3,800</td>
<td>Mar. 1</td>
</tr>
<tr>
<td>First life (cyanobacteria)</td>
<td>3,500</td>
<td>Mar. 25</td>
</tr>
<tr>
<td>Oxygen in atmosphere</td>
<td>2,000</td>
<td>Jul. 24</td>
</tr>
<tr>
<td>First organized cells</td>
<td>1,000</td>
<td>Oct. 12</td>
</tr>
<tr>
<td>First multi-celled animals</td>
<td>680</td>
<td>Nov. 7</td>
</tr>
<tr>
<td>First fossils</td>
<td>570</td>
<td>Nov. 16</td>
</tr>
<tr>
<td>First vertebrates</td>
<td>450</td>
<td>Nov. 25</td>
</tr>
<tr>
<td>First land plants</td>
<td>430</td>
<td>Nov. 27</td>
</tr>
<tr>
<td>First fish</td>
<td>400</td>
<td>Nov. 29</td>
</tr>
<tr>
<td>First amphibians</td>
<td>365</td>
<td>Dec. 2</td>
</tr>
<tr>
<td>First insects</td>
<td>350</td>
<td>Dec. 3</td>
</tr>
<tr>
<td>First reptiles</td>
<td>320</td>
<td>Dec. 6</td>
</tr>
<tr>
<td>First conifer trees</td>
<td>300</td>
<td>Dec. 7</td>
</tr>
<tr>
<td>Extinction of trilobites</td>
<td>285</td>
<td>Dec. 9</td>
</tr>
<tr>
<td>First mammals</td>
<td>200</td>
<td>Dec. 15</td>
</tr>
<tr>
<td>First dinosaurs</td>
<td>200</td>
<td>Dec. 15</td>
</tr>
<tr>
<td>Opening of the Proto-atlantic</td>
<td>200</td>
<td>Dec. 15</td>
</tr>
<tr>
<td>First birds</td>
<td>160</td>
<td>Dec. 19</td>
</tr>
</tbody>
</table>
Hopefully, before long, you will accept that things behave differently at different pressure, temperature and time regimes than you expect based on your own experiences. It is also my hope that you will notice that nearly all of your surroundings are all influenced (or caused) by processes occurring in the Earth's interior.

**Topic Layout of this Book**

This book is laid out in three parts. In the first we consider the Earth as a whole. After a fairly extensive introduction to seismic waves we can discover the interior layers of the Earth. Before we can decide what these layers are made of we have to have an idea of the ingredients available, the overall composition of the Earth. We look into how the Earth formed by accretion in a planetary nebula, then how the Earth fractionated into layers, including the tectosphere (rocky interior), the hydrosphere (oceans, rivers, lakes, etc) and the atmosphere.

In the second section of this book we consider the Earth's layers from inside to out: the Core, the Mantle and the Crust. In each case we investigate the evidence for the layer's composition and discuss important properties and processes taking place in that layer. This becomes more difficult as we reach the Earth's crust because we can observe it directly so we know more about it, but also because the active processes of the Earth's interior result in a great deal of heterogeneity. Plate Tectonics is introduced following the section on the Earth's Mantle and Oceanic Crust because it is an outgrowth of processes driven by heat from Earth's deep interior.

The final section of the book covers the natural disasters of earthquakes and volcanic eruptions. Of Earth's surface processes that impact humans, these are most directly due to processes driven from Earth's interior. Other natural disasters such as hurricanes, tornadoes, floods, blizzards, drought are primarily driven by solar heating of the atmosphere. These are best covered in another context.