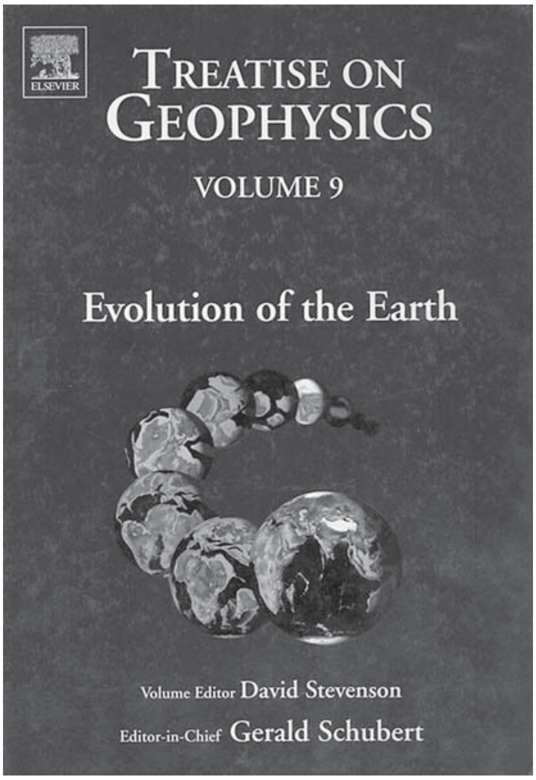
Treatise on Geophysics*, by Gerald Schubert (Editor-in-Chief) − Volume 9: Evolution of the Earth, edited by David Stevenson, 2007. Elsevier, P.O. Box 211, 1000 AE Amsterdam, The Netherlands. 11-volume series, all hardbacks, totalling 6054 pages. Price EUR 3586.00; USD 5245.00; GBP 3220.00. ISBN 978-0-44-52748-6.



We may wonder whether all the elements present in our body, in the food we eat, in the paper we write on, and consequently all the elements of the Earth and other planets were not formed in several stars − now non existent − at different stages of their evolution! Yes, that exactly is the fact, as clearly mentioned in the first chapter of volume 9 of the 'Treatise on Geophysics', where it reads: " ... 'provenance': the nature and origin of the material that went into making earth. This is our cosmic heritage ..."

When we compare the fragments of undifferentiated asteroids (chondritic meteorites) with the present-day Earth, we find their bulk composition similar, but the asteroids are chemically homogeneous whereas the Earth has a chemically layered structure. This indicates that the crust, mantle and core of the Earth must have developed, subsequent to Earth's formation, by a process that apparently did not operate in the primitive asteroids. The primeval rocks of meteorites, and therefore those of all planetary bodies of the solar system, were formed during planetary accretion by a process of agglomeration of mineral grains condensing from the solar nebula. So it appears that the processes of magmatism, sedimentation and metamorphism giving rise to igneous, sedimentary and metamorphic rocks started at a later time. The Earth formed 4.6 billion years ago, but the continental crust is not that old, and the traces of life found in rocks are not older than 3.8 billion years. These figures mean that the primitive Earth lacked the continents and the biosphere, which developed subsequently. It has also been evidenced that the crust of the Earth is not static but is rather in a state of motion and has always been so.

The Earth is a planet that undergoes continuous changes, steady-unsteady, recurring-nonrecurring and mostly irreversible. Why has the Earth been suffering continual changes, while most of the chondritic parent bodies remain as they were at the beginning of the history of the solar system? The answer is simple: the Earth possesses the energy to drive changes. It is the internal thermal energy (heat) that has driven and is driving, directly or indirectly, the various changes that have occurred and are occurring within the Earth. Volume 9 of the 'Treatise on Geophysics', entitled 'Evolution of the Earth', deals with several aspects of temporal evolution of the Earth and is a must-read for science students of all disciplines.

The book begins with a state-of-the-art review of the formation of the solar system, including moon formation, followed by a comprehensive summary of Earth's major reservoirs and composition. The presence of volatile matter in some meteorites suggests that the dust cloud from which the planets formed was relatively cold. On the other hand, the present-day Earth contains a lot of thermal energy, and the temperature increases with depth up to 8000 °C at the centre. So it is clear that the Earth gained much of its thermal energy during and after its formation. The heat of the Earth continually radiates away into space. In fact, the necessity of heat dissipation drives all dynamic activities of the Earth, making it gradually colder and colder. In contrast, the meteorite parent bodies changed very little after their formation because they dissipated their heat rapidly due to their small size.

The Earth, however, continues to retain the heat because of its greater heat content and very low rate of heat flow. The factors responsible for the heating of the Earth during its infancy are: (1) decay of short-lived radioactive isotopes that have become extinct and (2) impact of solid bodies pulled by the gravitational attraction of the growing Earth during the process of accretion. These two processes of heat generation increased the temperature of the Earth enormously and led to the formation of a silicate magma ocean and of the metallic core. The accumulation of liquid iron and nickel at the centre of the Earth is a kind of process whereby gravitational (potential) energy is released. The formation of the Earth core was therefore followed by the release of huge amounts of energy in the form of heat. With a continuous outward directed heat flow, the temperature of the metallic liquid core gradually declined and the liquid iron and nickel started solidifying. This process of solidification started from the centre and is still continuing. As a result, the Earth now has a solid inner core and a liquid outer core, both being similar in composition. The overlying silicate melt also started solidifying and gave rise to the crust and different layers of the mantle. The next major event of the Earth was the formation of the hydrosphere and biosphere.

The thermal evolution of the core and mantle is treated in detail in the book, pointing towards the inference that the various activities of the Earth reflect one single process: heat dissipation. In other words, all the dynamic processes operating on the Earth − volcanism, earthquakes, rock formation, lithosphere movement, mountain building, opening of oceans and so on − continuously combust and let out the Earth's heat content. So, a time must come in the geological future when all the thermal energy of the Earth will have been spent, so that the Earth becomes cold to the bones.

This is only a glimpse of what is stored in this book, which should be shelved in our libraries.

Chandan Chakraborty
Geological Studies Unit
Indian Statistical Institute
203, B.T. Road
Kolkata 700108
e mail: chandan@isical.ac.in

*editorial note: Elsevier understandably did not provide all 11 volumes for review. We have chosen Volume 9, as this volume may be the most interesting for the entire readership of our journal.