Earthquake Studies in Peninsular Shield Since 1993. H. K. Gupta and G. D. Gupta (eds) Memoir 54, Geological Society of India. P. B. No. 1922, Gavipuram, Bangalore 560 019. 2003. 254 pp. Price: Rs 450.

The Indian shield experienced several earthquakes in the last three to four decades, exemplified by the ongoing seismicity around Koyna registered since 1967, the 1993 Latur earthquake, the 1997 Jabalpur and 2001 Bhuj earthquake of moderate to high magnitudes. In response to these events, several parallel streams of investigations have been initiated that are of relevance to promoting an understanding of crustal processes that lead to seismogenic deformation on the one hand, and earthquake engineering, on the other. The main impetus to these researches has emerged after the 1993 Latur earthquake. The Department of Science and Technology stands foremost among several institutions in organising these researches and has effected an inter-institutional interaction and brought together several individual researchers in the field of seismology. The articles in this volume are illustrative of the great strides being made as a result of these efforts. It is a forerunner of several new strides that are flowing out of the current efforts.

As deformation is only rarely expressed in surface ruptures (faults), understanding the kinematics of the deformation has been largely based on instrumental data. The Latur earthquake, however, is a rare example where the co-seismic surface ruptures are present and have facilitated investigations through four bore holes drilled in the rupture zone. The results throw light on the deformation of a 338 m thick sequence of the volcanic flows of Deccan traps, underlain by some 8 km of sediment lying on an Archaean crystalline basement now dated 2574 million years. Thrust-faulting is traced to depths of 222 m, and large cumulative displacements of 3 to 6 km along the fault are encountered as against a submetre-scale co-seismic displacement inferred due to the 1993 event. This leads to possibilities of palaeo-seismic events in the region and a seismic ancestry that has the potential for estimating recurrence periods of earthquake on the Latur fault. The thermal regime measured in the bore holes confirms a cold crust that has no memories of the 65 million-year-old Deccan volcanism. The stress fields are 30% higher than comparable intracontinental regions and possibly the region up to Hyderabad may be sharing such a stress field. These may have implications in understanding the incessant but low seismicity of Hyderabad region.

Results of electromagnetic experiments reveal an intracrustal layer of conductivity at depths of 10–15 km below Latur and adjoining areas. This confirms earlier findings and underlines the role of fluids in effecting pore pressures that have the potential to generate fault failure and seismogenesis and to influence the overall rheological response of the shield in these regions.

The 1964 Koyna earthquake brought to prominence a centre of seismogenesis, characterized by a puzzling sequence of recurrence and migration of deformation from Koyna to the Warna area in the south. Clustering of foreshocks of eight moderate-magnitude and more recent earthquakes has thrown fresh light on the style of the nucleation process, thus enhancing our understanding of the source mechanisms in this region.

A notable contribution emerges from revisiting the regions of surface deformation due to the 1819 Kachchh earthquake, one of the rather rare large-magnitude and geologically unique seismic events in the world. The earthquake gave rise to a 90 km long tract of elevated land visible even today with a peak height of 4.3 m. Detailed information on deformation and liquefaction episodes of the pre-1819 period that point to a large magnitude event 800–1000 years earlier, suggest that the Allah Bund may have formed by possibly three repetitive earthquake events. Seismic activity seems to be related to the reactivation of an ancient rift in a stress regime now under compression, through a mechanism of fault propagated surface-folding. This tectonic model may have wider applications.

The newly-established network of broadband and short-period digital seismographs in the Indian shield offers great scope to generate new data on the crustal structure of the Indian shield and the source parameters of earthquakes. The past experience in this regard is succinctly reviewed in a significant contribution. The possibilities of using the seismic stations for monitoring controlled seismological experiments and to generate both *P*- and *S*-wave velocity structure are emphasized.

Analysis of the morphotectonics of the Konkan coast leads to conclusions of seismogenic character of several fracture lineaments along the Konkan coast.

The gravity fields across the western continental margins are used to generate larger insights into the structure and tectonic evolution of the Kerala basin, especially after the 65 million-year-old rifting and accompanying Deccan volcanism.

GPS and geodetic studies have been initiated both in Bhuj and in the Deccan volcanic province, including Central India, the site of the 1999 Jabalpur earthquake, and a tract along the east coast. Some interesting, though tentative, results of crustal displacements, velocity and strain rates are inferred, which need further confirmation. More extensive and repetitive measurements over larger areas that ensure a high resolution seem necessary.

Earthquake engineering is an area of great terminal importance to seismology. Studies carried out in different floors of the Regional Passport Office, Ahmedabad provide information on the structural response of a large building to earthquakes. The study provides a model approach that can promote more extensive application.

The concluding parts of the volume present three papers that provide a detailed account of the recently-upgraded and newly-established seismic monitoring centres in the country through both World Bank-assisted projects and national efforts, whereby we now have a national seismological network comparable with some of the advanced seismic networks in the world. An important part of this set-up are the modern computing and data centre facilities that have been created. These facilities, no doubt, have already registered a phenomenal impact on the quality and dimensions of seismological researches in India. The extensive facilities built up call for interaction and collaborative efforts on a massive scale, involving not only national laboratories but the IITs, universities and other advanced teaching institutions in India. The publication under review visualizes and anticipates such growth.

The editors deserve to be congratulated for bringing together a timely publication of some of the early significant results of the seismological researches initiated since 1993. The publication is well-illustrated, with a number of both coloured and black-and-white diagrams and has a commendable get-up. The volume would interest earth scientists, particularly seismologists and geologists alike, who are interested in the study of earthquakes. It will be a welcome addition to all earth sciences libraries.

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The Dynamic Structure of the Deep Earth: An Interdisciplinary Approach. Shun-ichiro Karato. Princeton University Press, 41 William Street, Princeton, New Jersey 08540, USA. 2003. 241 pp. Price not mentioned.

The theory of plate tectonics revolutionized our perception of the solid earth – from static to dynamic. It also explained most earth processes such as mountain-building, earthquakes and volcanic activity and went farther, to explain more enigmatic processes such as the deep earthquakes. Today, we know that the earth's interior is as active as its exterior, and what we see on the surface are the results of deeper processes. Clearly, we can appreciate the dynamic processes in the earth's interior, only by understanding the properties of materials in the conditions prevalent there. There are many books that deal with these issues in rather conventional ways, but few that go into details of how the material properties change dramatically in the deep interiors of the earth, and how these properties drive the engine of plate tectonics. The book under review is an effort in that direction and it is an authoritative summary of current researches in this field; with the author's own critical evaluation on some of the theories. He has diligently translated the dynamics of some of the complex processes that go on within the earth, into a well-researched and easy-to-understand account. This book takes us on a journey, starting from the atomic-level behaviour of earth materials, effortlessly guiding through its transformations under extreme conditions of temperature and pressure, finally leading to a global-scale assessment. The author knows that some of us who are unfamiliar with the turf, may find this a tough going, and therefore he provides us with all the necessary tools, excellent illustrations and more information in the boxes, to make this journey easier.

The first chapter of this book, the structure of earth and its constituents, reviews various models that explain the radial structure, chemical composition and phase transformations. Starting with early theories on chemical and geophysical models, this chapter brings up many later ideas such as the layered structure of the earth and phase transitions. At this early part of the book, the author introduces many concepts that are derived from observations of seismic waves. This chapter deals with geochemical, geophysical and seismological models (such as the Preliminary Reference Earth Model). Results from high-temperature mineral-physics experiments and observations from seismic waves (body waves, surface waves and free oscillations) are integrated to obtain an image of the earth's interior. A good part of this chapter is devoted to discussions on the thermal structure of the earth. Fundamentals of heat transfer, and the concept of anelasticity and how it affects attenuation of seismic waves are lucidly explained. The section on rheological structure is particularly well-written.

Mechanical layering in the upper mantle as the strong lithosphere and weak asthenosphere, is the key to the operation of plate tectonics on earth. Traditional understanding of the existence of asthenosphere is based on ideas of partial melting. Recent views based on studies in mineral physics, particularly simulations in the laboratory suggest how a small amount of water can have dramatic effects on the physical properties of minerals. The second chapter of this book reviews various models on the origin of the structures in the upper mantle and demonstrates the role of water in its mechanical stratification. Several interesting questions are raised in this chapter; some of them are addressed in detail, on the basis of new experimental data. For example, what is the cause of the drastic change in elastic and plastic properties of the asthenosphere? Why is there a distinct low-velocity and high attenuation in the upper mantle? A review of the current ideas and new experimental results presented in this chapter exposes the reader to the lattice-levels of plastic deformation, providing newer insights to the process within the asthenosphere. In the new lithosphere–asthenosphere model, various geophysical anomalies (low seismic velocity, high electrical conductivity and low viscosity) are caused by the large amount of water dissolved in mantle minerals.

In the third chapter on seismic tomography and mantle convection, the author summarizes the recent results of seismic tomography and other high-resolution seismological experiments. Tomography, the most recent tool that uses seismic wave velocities to map structures, has given us vivid images of the upper-mantle heterogeneities (caused by physical environment as well as chemical composition). This chapter examines results of such high-resolution experiments that have provided the most efficient tools to understand the structure of the earth. The way anisotropy is handled in this chapter is an illustration of how the author develops an idea from the atomic-level, taking it to grain-level and finally to the global scale. Results from high-pressure mineral and rock physics and seismology merge here, to give us a clearer view of the dynamics of some of the earth processes.

About 70% of the heat flux from the earth is released by plate tectonics, and there is a fairly good understanding of how materials have been circulated by plate tectonics for the past ~200 million years, at least to about 700 km, the depth to which the fate of the subducted slabs can be traced (also the limiting depth of earthquakes). One of the important processes in mantle circulation is the recycling of the oceanic crust. An intriguing question is whether the subduction of the oceanic lithosphere is limited to 700 km. And what mechanism can separate these geochemically distinct portions for 2–3 billion years? Improved understanding of the rheological properties of the earth aided by the developments in experimental techniques of high-pressure deformation may provide more insights into these problems, as the author predicts in the end of this chapter.

One of the intriguing questions on earth processes concerns the origin of deep earthquakes, the topic of the fifth chapter of this book. All the three mechanisms proposed for the origin of deep earthquakes – dehydration embrittlement, faulting induced by phase transformation