Chapter 1
Introduction to Geodynamics of the Indian Plate: Evolutionary Perspectives

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The Indian region is a peninsula that is bordered by the Himalayan Orogen in the north, the Indian Ocean in the south, the Bay of Bengal in the east, and the Arabian Sea in the west. It forms part of the Indo-Australian Plate; and has four physiographic provinces—(1) the Peninsular, (2) the Indus-Ganga-Brahmaputra Plain, (3) the Thar Desert, and (4) the Himalayas. The geological structure of the Peninsula constituted of Central and Southern India evolved through the assembly of four major Archaean cratons and several Proterozoic mobile belts. The Precambrian basement of the Indian Shield together with the Precambrian sedimentary basins are overlain by the sedimentary sequence of the Himalayan Foreland, in the north and the end-Cretaceous Deccan Flood basalts in the west and central regions of India. Basins related to rifting episodes of the Indian landmass—the Gondwana basins and the pericratonic basins along the eastern and western margins of India—formed in the Paleozoic-Mesozoic. In the Cenozoic, the Himalayas and its foreland were initiated and continued to develop in response to the northward migration of the Indian Plate, and its subduction beneath the Eurasian Plate and collision. These latter geodynamic events resulted in the development of strong interconnections between mountain-building, climate, and erosion—a subject that has continued to hold attention over the past few decades. The geodiversity of the Indian Plate is remarkable and as seen from the above account has been developed through the last 4 billion years of Earth history. The present volume attempts to provide glimpses of the evolutionary trajectory that has led to the geodiversity of the Indian Plate.

Chapter 2 by Jayananda et al. reviews the processes that led to early Earth conditions including thermal records, mantle evolution, crustal growth, craton formation, and tectonics, followed by the evolution of cratonic blocks and their assembly into

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the Peninsular Shield. Chapter 3 by Sarbani et al. deals with tracking India within supercontinent cycles. Vast terrains of Precambrian rocks in various geological provinces of India provide valuable clues to global tectonic reconstructions and the "sojourn of Indian Plate from the Archaean through the Proterozoic against the models of supercontinent assembly and break up." Chakraborty et al., in Chap. 4, draw our attention to the less disturbed and unmetamorphosed platformal sediment packages hosted within the cratonic nuclei of Peninsular India and their utility in understanding the profound changes in the atmosphere, hydrosphere, and biosphere during the mid- to late Proterozoic. Further, this chapter has also explored the possible connections of these basins with the supercontinent cycles of Columbia and Rodinia. This is followed by Chap. 5 by Mukhopadhya, who has reviewed the geological/geochemical evidences, particularly the occurrences of pyritiferous-uraniferous reduced paleoplacers, distribution of banded iron formations (BIFs) through the ages, Fe-depleted reduced paleosols, and the mass-independent multiple sulfur isotope fractionation of their isotopes. Chapter 6 by Das and Gupta highlights the use of biostratigraphy, chemostratigraphy, and geochronology in understanding the Proterozoic record of life in India with an emphasis on the Mesoproterozoic, Neoproterozoic, and the Ediacaran Period. Following these five contributions related to the Precambrian evolutionary history of the Indian Plate, Ghosh and Sengupta (Chap. 7) have provided a summary account of the stratigraphy and paleontology records of the Indian Gondwana strata that accumulated in a number of discrete basins in the rift settings of the Indian landmass. Sedimentation in the Gondwana basins started in the Late Carboniferous and continued till the later part of the Triassic period, and in places till the Early Jurassic. These few kilometers thick fossiliferous, mostly continental deposits provide insights into paleoenvironments, biotic evolution, climate change, and paleogeographic configuration of the Gondwana basins. Chapter 8 by Vivek Kale presents a detailed account of the Cretaceous Flood Basalt (CFB) that is linked to the passage of India over the Kerguelen and Reunion hotspots in succession resulting in the formation of the 113–118 Ma Rajmahal-Bengal-Sylhet Province in the eastern parts of the Indian Plate, and the latter in the 61–68 Ma Deccan Volcanic Province, which has been extensively debated to be one of the causes of the end-Cretaceous mass extinction. In the ensuing Chap. 9, Prasad and Parmar explore the "Big Five" mass extinctions through the Indian stratigraphic records. These mass extinctions include the end-Ordovician, the Fasnian-Fammenian boundary of the Devonian Period, the Permian-Triassic boundary, the Triassic-Jurassic boundary, and the Cretaceous-Paleogene boundary. A summary of the biological and geological events, geochemical anomalies associated with these mass extinction boundaries is provided; and potential causes for these mass extinction events such as bolide impacts, volcanisms, sea level changes, ocean anoxia, and methane hydrate release have been discussed.

Following the overview from the Archaean through the Paleozoic and the Mesozoic, Jain (Chap. 10) explores the geological evolution of the Himalayan mountains. He has emphasized that the Indian Continental Lithosphere was first subducted under the Trans-Himalayan Ladakh magmatic arc at about 58 Ma; the Himalayas then emerged from this deeply subducted terrane between 53 and 50 Ma, followed by sequential subduction and imbrications of the Indian Continental Lithosphere. Chakraborty et al. (Chap. 11) provide a summary of the Himalayan Foreland with respect to the fills, dispersal patterns, and detailed paleoenvironmental reconstructions of the eastern Himalayan foreland. They show that the sea receded from the western part of the foreland by Early Miocene while a shallow marine/deltaic environment persisted till the Pliocene in the eastern part of the foreland. The factors that led to the diachronous retreat of the sea are also discussed in this Chapter. The southern boundary of the positive topography of the sub-Himalayan Siwalik hills with the Indus-Ganga-Brahmaputra Plain is marked by the Himalayan Frontal Fault Zone and its active tectonics (Thakur et al., Chap. 12). The Frontal Fault Zone includes the frontal anticlines, the dun basins, and the foreland thrust systems. According to Thakur et al., the frontal anticlines are developed in fault-bend folds over the Himalayan Frontal Fault. The back limbs of the frontal anticlines are characterized by intermontane basins and their fills extending back over time scales of 100,000 a. Also, the active tectonics of this zone has been linked to the seismicity and paleoseismology of the region. The extensive Ganga Basin and its near surface component, the Ganga Plain, lie farther to the south of the HFT and are filled by several kilometers thick sediment successions belonging to the Neogene and Quaternary. The Late Quaternary evolution and the morphostratigraphic development of the Ganga Plain has been reviewed by Khanolkar et al. (Chap. 13) and provides insights on the relative roles of various forcing functions that governed sediment accumulation patterns in time and space in the Ganga Plain. The Ganga Plain is broadly divisible into an Eastern Ganga Plain dominated by Mega-fans and inter-fan areas and a Western Ganga Plain dominated by incised valleys and their intervening interfluves. This geodiversity has generally been attributed to the differences in stream power, sediment yield, and subsidence patterns of these two mega-geomorphic domains, a general consequence of the along-strike variations in uplift-erosion relationships along the length of the Himalayan Orogen. Also, stratigraphic development in the Late Quaternary in the southern part of the Ganga-Yamuna interfluve appears to have been influenced by the changing discharge regimes resulting from monsoonal shifts.

As noted above, there has been a complex interplay of tectonics, climate and erosion during the Cenozoic in this region. The Indian monsoon represents a complex oceanic-atmospheric coupled mechanism of the tropics. Gupta et al. (Chap. 14) have recognized several phases of strong summer monsoon rainfall caused by changes in various forcing functions. The initiation and strengthening of the Indian monsoon are linked with the major surface uplift of the Himalayan/Tibetan Plateau. The Plio-Pleistocene glaciation resulted in a strong winter and weak summer monsoon. These authors have gone on to trace the monsoon shifts through the Holocene, the Medieval Warm Period, and the Little Ice Age. Finally, they indicate that meteorological records show an increasing trend in the intensity and frequency of extreme rainfall events. The final chapter (Chap. 15) of this volume by Pattnaik and Dimri discusses the subject of climate change over the Indian subcontinent. They concluded that the annual mean temperature over the Indian landmass reveals an increasing trend of 0.64 °C/100 years with a significant increasing trend in maximum temperature, and a relatively lower increasing trend in minimum temperature. Also, as per their analysis the JJAS monsoon rainfall does not show any overall significant trends during 1901–2016; although, epochal variations are observed.