

Preface

Time to time in the past two decades, my research collaborators in India and abroad, also others passionately involved in the progress of Indian geology, even students in India, particularly at BHU, desired of me a book on my comprehension of the Indian Mesozoic sequences. Near my formal retirement in 2010 came ‘The Making of India’, an immensely inspiring magnum opus on Indian Geology, written by my revered guru (teacher) Prof. K.S. Valdiya. This also kindled the fire in me to go for an exciting post-retirement innings. Once formally free from teaching and sponsored research in 2014, I began scribbling my comprehension of the Kachchh Mesozoic. As I continued mostly in early morning sessions in Varanasi, Gurgaon, and Bangalore, the canvas of the project went on assuming yet larger dimensions than originally contemplated to engulf the entire Gondwanian Tethyan Margin from Arabia to Australia.

The whole array of integrated progress in the Indian Mesozoic geology, realized since my initiation in the Indian Mesozoic in the mid-1960s, is interwoven with the innovative threadwork of sequence stratigraphy. The key to the study is development of ammonoid-based high-resolution zonal scales in the Indian Triassic and Jurassic comparable to the best of the world, while the Cretaceous is considerably reinforced with the composite records of ammonoids, foraminifers, dinocysts, and nannoplanktons.

Emphasis is placed primarily to high-quality lithostratigraphic differentiation along with meticulous recording of the sections, bed by bed ammonoid collection in the field, and the resultant ammonoid stratigraphic range charts based upon comprehensive taxonomic studies in the laboratory. The cardinal requisite of good stratigraphic refinement has been the differentiation of a large number of stratigraphically precise ammonoid bearing levels, in several fold larger number of beds in the sedimentary column, to ensure the development of near-optimum number of zones/subzones/horizons as the best measure of quality refinement. The ammonoid-based ~25 zone succession in the ~25 my long Bathonian–Tithonian scale of Kachchh is uniquely developed in a single superfamily—Perisphinctaceae, that too near exclusively in the Kachchh basin.

The author's attraction to sequence stratigraphy stemmed primarily from it being an effective powerful tool to unify the highly kaleidoscopic array of apparently disjunct geological facets strewn over large regions of the like of Indian subcontinent. His understanding of sequence stratigraphy has been an integrated refined chronostratigraphically controlled realistic comprehension of rock relationships of genetically related cyclic strata, units, events, and geological phenomena based on sedimentology, paleontology, eustatics, tectonism, magmatism, and many other such interrelated subdisciplines.

The eventful Mesozoic has been the game changer of the earth's Phanerozoic history, especially in the Indian context. Indian Mesozoic studies have been done mostly in isolation at basinal level, only occasionally extending to specific sectors. Compilations lack the very element of life and dynamism. The Cretaceous in Spiti is seldom related to Cauvery, or to that of Kachchh, or Triassic of Kashmir to that in Myanmar. It is this holistic subcontinental approach that has been endeavoured through the application of sequence surface timelines across the subcontinent and even beyond on the Gondwanian Tethyan margin.

The Indian Late Precambrian–Neogene record is organized into five mega-sequences. The fourth among them—also the most important one—spans through the intra-Permian–intra-Paleocene interval from the origin to the closure of the Neotethys. It is further differentiated into three first-order sequences, 35 second-order sequences, and then several second-order sequences into third-, fourth-, and fifth-order ones. The first-order sequences are developed in Spiti Himalaya (intra-Permian to Pliensbachian), in Kachchh (Toarcian to Barremian), and compositely in Cauvery, Spiti, and Kachchh (Aptian–Paleocene), and subsequently extended on either side of India from Arabia to Australia.

The mega-sequence began with outpouring of the Panjal and coeval volcanics. The first-order sequences are found punctuated by major Gondwana dismemberment extensional tectonics and magmatism at the ~183 ma intra-Jurassic Karoo and coeval volcanism with principal manifestation in the west sector, intra-Cretaceous ~126 ma Rajmahal and coeval volcanism with cardinal expression in the east sector as the intervening first-order SBs. The first-order MFSs, respectively, signal the initiation of oceanization in the northwest spreading away of the Aargo block in northeast at the ~159 ma intra-Oxfordian MFS, and farther up the initiation of spreading between India and Madagascar at the ~92 ma intra-Turonian MFS. The mega-sequence formally closed soon after the termination of Deccan magmatic event, yet notional closure of the Neotethys stretched farther into Paleogene collision of India and Asia.

The validation of the developed first/second-order sequence framework in east and west of India on the Gondwanian Tethyan Margin is realized through comparison with Arabia, East Africa, Madagascar, Pakistan, High Himalaya, Indonesia, Papua New Guinea, Timor, West Irian, and NW Australia. The first- and second-order sequence surfaces are consequences of intra-basinal to inter-regional tectonics and geographically restricted to broad tectono-stratigraphically homogeneous regions of the Gondwanian Tethyan Margin in the present study. The

resultant sequence surfaces are often found discordant to those of other such regions, for example, to the Eurasian Tethyan Margin framework. On the contrary, the third- and finer order sequences shorter than $\sim 1.5\text{--}2.0$ my are governed by earth's orbital dynamics, and thus found globally isochronous.

Comparison of the Indian sequence framework also includes important hydrocarbon-producing regions and basins across the Indian divergent margins both in east and west; and based there upon, a highly positive scenario of the Indian Mesozoic hydrocarbon perspective of source/reservoir rocks is outlined in sequence stratigraphic backdrop as an edifice for elaborate evaluation in near future.

The Indian Mesozoic geological developments irrespective of location in east, north, south, or west sectors, whether in intra-cratonic or peri-cratonic rift basins, frontier or foreland basins, marine or non-marine, guide-fossil bearing or devoid, in carbonate or clastic facies, exposed, onshore, or offshore, deep or shallow, in Indian ocean or South Tibetan collision arena are considered genetically related resultants of the same regional tectonics, allowing correlation of units and chronicle of regional events through the all-pervading sequence surface timelines. So time corresponded the magnetic anomalies, origin, climax, and termination of igneous activities, eustatics, climatic and anoxic events, breakup, dispersal, and collision episodes, rifting, transform sliding, and spreading phases in an alternative innovative sequence stratigraphic context. The single all unifying sequence surface ages are found echoed through highly precise SHRIMP zircon, U/Pb, and Ar40/Ar39 radiometric ages, mega/micro faunal/floral records, and magnetic anomalies through the span of the mega-sequence almost equally strong from all the sectors and varied geological settings of the region as unanticipated strong support to interdisciplinary manifestations of a single spreading framework encircling and engulfing the Indian plate.

In the precision chronicle of the multifaceted happenings at sub-zonal resolution and multiples in east, west, north, and south, the plethora of litho-stratigraphic unit names has been largely done away with and rather made redundant. The large intra-Jurassic stratigraphic gap in Kachchh with increase in duration from margin to basin, has been précised in different sections, and its long held interpretation radically revised from subaerial to submarine all over the GTM from Arabia to Australia. Other major gaps of the Indian geological record are also differentiated as subaerial or submarine. All the formations and members throughout the basin have been precisely age ranged. Ammonoid heterochronic evolution, geography, expansion, and migration events back and forth Indian subcontinent during the Jurassic are also outlined in first- and second-order sequence stratigraphic context.

Ammonoids as guide fossils provide a singular advantage to its researchers. Even a single incomplete fragmented specimen when found, much like the aircraft black-box, starts unfolding the geological history like a time machine on the outcrop itself as if the specimen itself is in a narrative conversation with the discoverer. It is these conversations with ammonoids on the outcrops, and discourses on the

ammonoid bearing and coeval Indian Mesozoic sequences in the classrooms, seminars, and conferences, that I, in the form of this book, present unto the learned Mesozoic geoscience and allied scholars, researchers, teachers, and professionals across the world.

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