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Geological Structure

INTRODUCTION

The geological structure, which includes the arrangement and deposition of rocks in the earth's crust, plays a dominant role in determining the relief of land and nature of soil. It also helps in knowing about the vast mineral wealth buried beneath the earth's surface. As such, study of geological structure plays a vital role in agricultural and industrial growth and in the economic prosperity of the country. For example, the vast alluvial Indo-Gangetic plain has very fertile soils and is extremely useful for agriculture. But it is almost completely devoid of any mineral deposits worth the name. On the other hand, igneous and metamorphic rocks of the peninsular plateau, especially those of the Chotanagpur plateau are very rich in mineral resources. Similarly the study of geological structure helps in landuse planning, development of transport and communication lines, increasing potentials for irrigation, determining the quality and quantity of ground water resources and understanding disasters like earthquakes, volcanoes, landslides, floods, etc. Therefore, it is necessary for us to study the geology of India before we proceed to learn more about the geography of the country.

Geological Regions of India

Geologically, India is divided into three regions, *viz*., (1) *the Peninsular region*, including the Meghalaya plateau in the north-east and the Kuchchh-Kathiawar region in the west; (2) *the extra-peninsular region*—the Himalayas and their eastern extensions including Andaman and Nicobar Islands and (3) *the Indo-Gangetic plain*, between Peninsular and exra-peninsular region.

Although the *triple tectonic division* of India as mentioned above is generally held valid and is readily accepted by majority of geologists, some scholars recognise only two geological divisions of India *i.e*. the *Peninsular* block and the *Extra-Peninsular* region comprising the Himalayan ranges and the Indo-Gangetic plain. These macro-regions present most striking geological contrasts. The Peninsula is one of the oldest land-masses of the earth and is dominated by open senile topography. The Extra-Peninsula, on the other hand, presents the most youthful relief of the earth in the form of the Himalayas. The alluvial filled Indo-Gangetic plain presents flat, featurless and monotonous topography. The Indian Peninsula has not undergone marine submergence since the *Cambrian period* and is not much affected by the tectonic forces. In contrast, the extra-peninuslar region has its origin in the Tethys Sea and is prone to tectonic forces resulting in devastating earthquakes. It is a weak and flexible portion of the earth's crust which has been folded, faulted and overthrust.

Geological History of India

Geologically India represents a monumental assemblage of rocks of different character belonging to different ages, ranging from pre-Cambrian (prior to 600 million years) to the recent times. Sir T. Holland of the *Geological Survey* of India has classified the rock systems of the country into following four major divisions :

1. The Archaean Rock System.
2. The Purana Rock System.
3. The Dravidian Rock System.
4. The Aryan Rock System.

The major geological systems of India are shown in Figure 2.1.

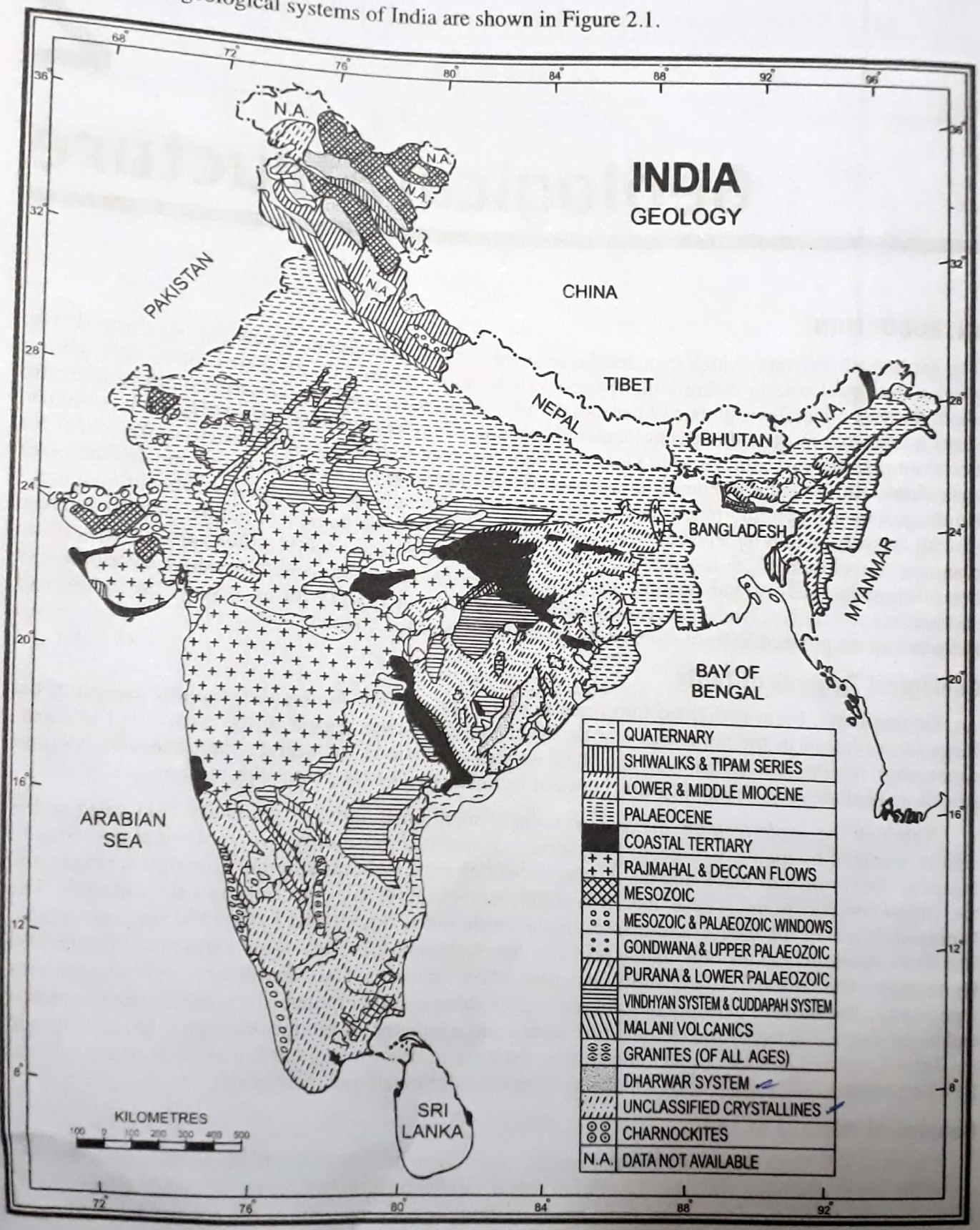

FIG. 2.1. India : Geology

1. THE ARCHAEAN ROCK SYSTEM

The word 'Archaean' was first used by J.D. Dana for rock structure prior to the Cambrian system. Obviously the Archaean rocks are the oldest in the world. The Archaean rock system includes the following rock groups :

(*a*) **The Archaean System-Gneisses and Schists**. These are the oldest rocks and were the first to be formed at the time of cooling and solidification of the upper crust of the earth's surface in the pre-Cambrian era (about 4000 million years ago). Although their broad characteristics are well known, the details of their origin continue to arise considerable speculation. They are all azoic, thoroughly crystalline, extremely contorted and faulted, often formed as plutonic intrusions and generally have a well defined foliated structure. They often underlie strata formed subsequently and the system is generally known by names of the '*Fundamental Complex*' or the '*Basement Complex*'. Their details are complex but recent advances in geochemistry are likely to enhance our understanding of their formation.

The most common Archaean rock covering about two-thirds of the Peninsular surface is the gneiss. This is the rock which in mineral composition may vary from granite to gabro, possesses a constant, more or less foliated or banded structure. The schists, mostly crystalline, include mica, talc, hornblende, chlorite, epidote sillimanite and graphite schists.

The crystalline metamorphosed sediments and gneissic rocks cover large parts of India. The central and the southern parts of the Peninsula are occupied by this rock system. To the north-east of the Peninsula, they occupy wide areas in Orissa, Meghalaya, Madhya Pradesh, Chhatisgarh and Chotanagpur plateau of Jharkhand. They also cover the whole of Bundelkhand in the north and to the north-west, they are found in a number of isolated outcrops, extending from north of Vadodara to a long distance along the Aravalis. In the extra-peninsula, these rocks are exposed all along the Himalayas, forming the bulk of the high ranges and the backbone of the mountain system (Fig. 2.2).

(*b*) **The Dharwar System.** This system derives its name from the rocks first studied in the Dharwar district of Karnataka where such rocks are found in abundance. The Dharwars include some of the highly metamorphosed rocks of both sedimentary and igneous origin. According to Wadia, the Dharwar System is the most ancient metamorphosed sedimentary rock-system of India, as old as, and in some cases older than, the basement gneisses and schists. He further adds that the weathering of the pristine Archaean gneisses and schists yielded the earliest sediments which were deposited on the bed of the sea, and formed the oldest sedimentary strata, known in the geology of India as the Dharwar system. Some of the metamorphosed rocks of the igneous origin are also included in this system. Most rocks of the Dharwar system are so metamorphosed that they are practically indistinguishable from their primitive formations. The major rocks of the Dharwar system are hornblende, schists, quartzites, phyllites, slates, crystalline limestones and dolomites. These rocks were deposited in three major cycles, the earliest one is over 3,100 million years old and the latest one about 2,300 million years. They were metamorphosed around 1,000 million years ago.

The Dharwar system is very well developed in the Dharwar-Bellary-Mysore belt of Karnataka. It also occurs in Jharkhand (Ranchi, Hazaribagh), Madhya Pradesh (Balaghat, Rewa), Chhatisgarh (Bastar, Dantewara, Kanker), Orissa (Sundergarh, Keonjhar) and in the Aravalis between Jaipur and Palanpur. In the extra-Peninsular region, the Dharwar system is well represented in the Himalayas both in the central and northern zones as well as in the Meghalaya plateau (Fig. 2.3).

The Dharwars are economically the most important rocks because they possess valuable minerals like high grade iron-ore, manganese, copper, lead, gold, quartzites, slates, mica, etc.

2. THE PURANA ROCK SYSTEM (1400–600 MILLION YEARS)

In india, the word purana has been used in place of Proterozoic and includes two divisions : the Cuddapah System and the Vindhyas.

The Cuddapah System. A long interval of time elapsed before the rock system next to the Dharwars and Peninsular gneisses began to be deposited. A great thickness of unfossiliferous clay, slates, quartzites, sandstones and limestones was deposited presumably in great synclinal basins. This

formation is known as the Cuddapah system, from the occurrence of the most typical and first-studied, outcrops of these rocks in Cuddapah district of Andhra Pradesh. Naturally the Cuddapah system is separated from the Dharwar system by a great unconformity. In some parts of southern India, we have the Cuddapah system amounting to 6,100 metres in thickness with several unconformities.

The most extensive occurrence of this system is in the Cuddapah district followed by the Kurnool district of Andhra Pradesh. The outcrop is of an irregular crescent shape concave towards the coast covering an area of about 45,000 sq km. The crescent shaped outcrops of the Cuddapah rocks suggest that the rocks were subjected to compressive forces directed from the concave side near which stood high mountains that supplied materials forming the rocks of the basin. Another large development of this system is in the southern parts of Chhattisgarh covering the districts of Dantewara, Bastar, Kanker, Dhamtari, Raipur, Durg and Rajnandgaon. A few isolated exposures occur in Singhbhum district of Jharkhand, Kalahandi and Keonjhar districts of Orissa and along the main axis of the Aravalli range from Delhi to Idar in Gujarat aggregating 5,200 metres in thickness at certain places. Some deposits of Cuddapah rock system are found in Karnataka also (Fig. 2.4).

The economic significance of the Cuddapah system lies in the fact that these rocks contain ores of iron, manganese, copper, cobalt, nickel, barytes, jasper, asbestos, steatite and cherts. They also contain large deposits of building purpose quartzites and cement grade limestones.

The Vindhyan System (1300-600 million years). This system derives its name from the great Vindhyan mountains although Spate has tried to distinguish between the Vindhyan rocks and the Vindhyan hills. The system comprises of ancient sedimentary rocks superimposed on the Archaean base. It is a vast stratified formation of sandstones, shales and limestones, often over 4000 m thick. Except a few traces of animal and vegetable life, this group is devoid of any recognisable fossils. Occupying a large area of over 1,00,000 sq km, the Vindhyan system stretches from Sasaram and Rohtas in western Bihar to Chittaurgarh in Rajasthan with the exception of a central tract in Bundelkhand which makes a gap in this belt. Large area of this belt is covered by the Deccan trap. The outcrop has the maximum breadth between Agra and Neemuch. These rocks are also found in Chhattisgarh, Bhima Valley of Karnataka and Kurnool district of Andhra Pradesh. The Vindhyan system has been found to continue to the north under the Gangetic alluvium and they are perhaps buckled down underneath the Himalaya. The rocks of the Vindhyan system comprise two distinct but unequal sets of deposits. The *Lower Vindhyan* (1,300-1,100 million years) is marine in origin, mostly calcareous in nature and shows tectonic deformation by folding movements. This system is well placed in the Son valley, in Chhattisgarh, in the valley of the Bhima and in a separate basin in Mewar. *The upper Vindhayan system* (1000 - 600 million years), on the other hand, is fluviatile in origin and is gently lying in undisturbed horizontal strata. The Lower and the Upper Vindhyans are separated by an unconformity which is quite prominent in the north but almost disappears in southern areas of Mewar, Chittaurgarh and the Son valley.

The Upper Vindhayan beds enclose two diamond bearing horizons, from which Panna and Golconda diamonds have been mined. The Vindhyan system, on the whole, is devoid of metalliferous minerals but provides large quantities of excellent and durable free stones, flagstones, ornamental stones, limestone, pure glass making sand and some coal.

3. THE DRAVIDIAN ROCK SYSTEM (PALAEOZOIC)

The rocks of the Dravidian system came into being about 600-300 million years ago. Most rocks of this system are found in the Extra Peninsular region and they are conspicuous by their absence in the Peninsular India except for one or two small patches of lower Permian age near Umaria. The Cambrian and Devonian rocks containing recognisable fossils are unknown in the Peninsula. The rocks belonging to the Dravidian System contain abundant fossils which help in determining correctly the age of the rocks and make correlation of rocks possible over distant areas. The rocks of Cambrian, Ordovician, Silurian, Devonian and Carboniferous periods are included in the Dravidian system.

The Cambrian rocks (600 million years) named after Cambria the Latin name for Wales in Great Britain, include slates, clays, quartzites and limestones. They are best developed in the north west Himalayan region. In the Spiti valley of Himachal Pradesh, there is an extensive fauna known as