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The Dynamic Tectonic Engine of Indian Sub-Continent: an overview

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Abstract
The Indian plate is essentially coincide Indian sub continental dimension. The Indian Plate is a major tectonic plate spanning the equator in the eastern hemisphere. Moving this plate and inter attract to the Eurasian plate the collision is activated as a result developed in fold mountain of Himalayas. The triangulated Indian plate is broadly expanded between the Indian Ocean and Himalayas and also visible the high concentration of northern movement of this plate. These mechanisms prove that the Indian plate is highly strength and more constructive by geological and physiographic set up of Indian continent. The Indian shield region consists of various complex rift zones and several shear/thrust zones. Indian shield region is categorized as Stable Continental Region. In this regard the peninsular plateau is a chamber of mechanical force which works as dynamic tectonic engine of Indian subcontinent and sub press the Indian plate northwardly. It is estimated that the peninsular plateau is most formational striking engine of the power and strength of Indian plate.
Keyword: Indian Plate, Eurasian Plate, Peninsular Plateau, Tectonic Engine, Structure, Geology, Alluvial Gangetic Plaines, Himalayan Mountain.

Introduction:
A plate is a large, rigid geospatial slab of rock which moves slowly over the asthenosphere. It's also continental dimensions. According to the Le pichone earth has classified 6 major plates Indian plates anther of this. The Indian plate is essentially coincide Indian sub continental dimension also. The Indian Plate is a major tectonic plate spanning the equator in the eastern hemisphere. Originally a part of the ancient continent of Gondwana, India broke away from the other fragments of Gondwana 100 million years ago and began touching north. Once fused with the adjacent Australia to form a single Indo-Australian Plate, modern studies recommend that India and Australia have been take apart plates for at least 3 million years and likely longer. The Indian plate includes most of South Asia i.e. the Indian subcontinent and a portion of the basin under the Indian Ocean.

Moving this plate and inter attract to the Eurasian plate the collision is activated as a result developed in fold mountain of Himalayas. Presences of major mountain group of the world are closely separated from the other continental slabs and close attached of the oceans. But unfortunately the world biggest mountain range could not carry these types of characteristics. The triangulated Indian plate is broadly expanded between the Indian Ocean and Himalayas and also visible the high concentration of northern movement of this plate. These mechanisms prove that the Indian plate is highly strength and more constructive by geological and physiographic set up of Indian continent.

The whole mechanism controlled by the structure of Indian physiography. The peninsular plateau play major striking role due to their deep geological set up and moved downward below the Eurasian plate developed the alluvial Gangetic valley as a rift valley and upward portion is established as a both Himalayan mountain

and peninsular plateau. In this regard the peninsular plateau works as dynamic tectonic engine of Indian subcontinent and sub press the Indian plate northwardly.

Objective:

i. To identify the location, structure and size of Indian subcontinent or plate.
ii. To examine the geological structural and physiographic set up of Indian subcontinent.
iii. To analysis the structural strength and stability of Indian shield.

Source of information & Methodology:
The geospatial study has been difficult due to collection of data and information. The several Books review, Literature review, Article review, Map analysis, Google earth image, GSI information report and published map are help to fulfillment of the study.

The dynamic tectonic engine:
Engine is a machine with moving parts that converts power into motion. In this case the machine related to the geological and physiographical structure, which moving parts converts to the power into the motion. The tectonic system which is involves the movement of lithospheric plates. The plates move seemingly independently, which indicates that the system is dynamic, i.e. material and energy move and change from one form to another. Regional stresses in lithospheres generate particular deformation subsystems with characteristic geometry, attitudes and organization, in particular at plate boundaries. Six fundamental structure subsystems (3 end members and 3 intermediate) are identified:

End member tectonic subsystems	Intermediate tectonic subsystems
Compressive system	Transpression system
Extension system	Transtension system
Strike-slip system	Syn-convergence extension systems

These subsystems, which contain structures of the same geological age, in response to the same tectonic processes, may cover enormous regions, e.g. 10 to 100 km in width for some 1000 km in length in orogens or passive margins. One can understand the relationship between these structure subsystems with a simple model, taking the round cover of a bin as a plate. It is strong and rigid. Place all around the bin-cover sand, which represents the weak ranges and/or sedimentary basins. Sand reacts to stress in a brittle manner like upper crustal rocks. What happens in sand when moving the bin cover?

1. A brittle compression system with thrusts develops in front of this experimental plate.
2. A brittle extension system with normal faults develops behind the plate.
3. Strike-slip systems develop on both sides of the bin cover, one clockwise (dextral) and the other anticlockwise (sinistral).

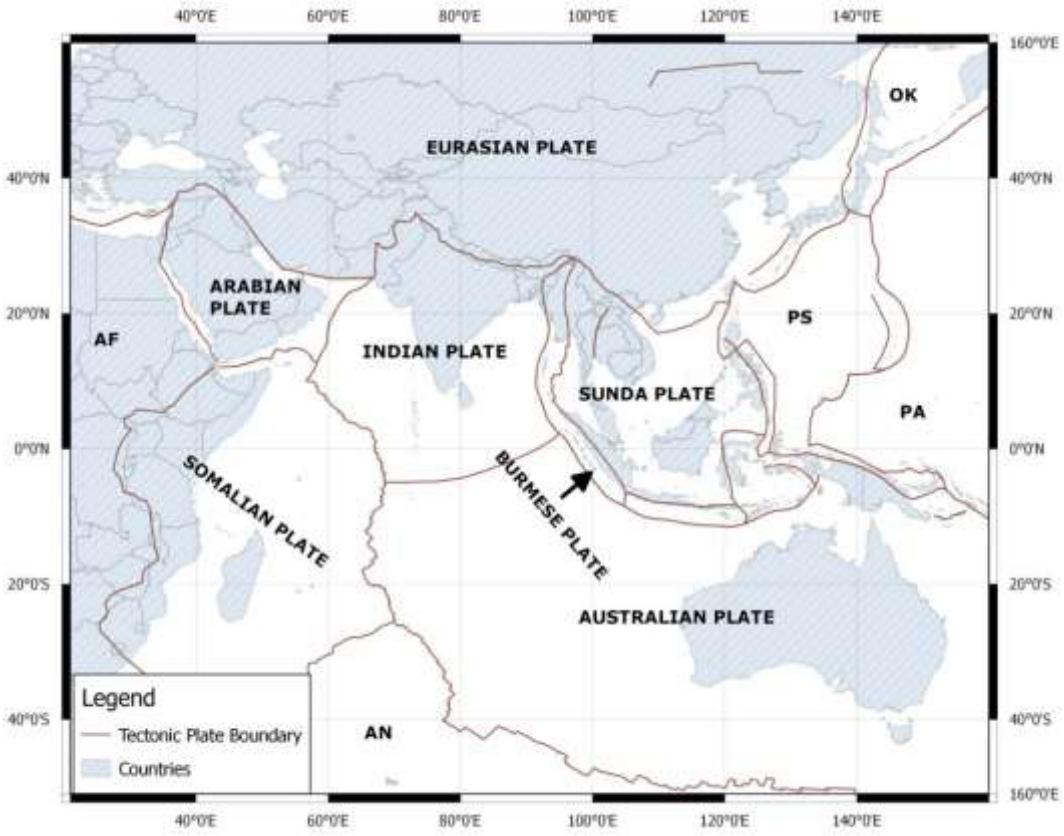
Location and Structure of Indian subcontinent:
The Indian mainland extends between 8°4′ North and 37°6′ North latitudes and from 68°7′ East and 97°25′ East longitudes. Thus, the latitudinal and the North-south extent is 3214 km and East-west extent is 2933 km. India accounts 2.42% of the total world land area India lies entirely in the northern hemisphere, and eastern hemisphere. The Tropic of Cancer (23°30′ North) passes through the centre of the country. It divides the country into almost two equal parts Northward of this latitude is North India and South of it is known as south India. Similarly 82°30′ East longitude passes almost from the middle of the country. It is known as Standard Meridian of India. India is surrounded by water from three sides. Arabian Sea in west, Bay of Bengal in the east and Indian Ocean in the south. Towards its north west is Pakistan and Afghanistan. China, Bhutan, Tibet and Nepal lies to its north. Bangladesh and Myanmar lies to its east.

Indian Tectonic Setup:

The Indian plate is bounded by zones of broadly distributed active deformation. The most widely distributed plate boundary in the world is actively deforming as continental India continues to collide with Eurasia. Beginning at the northern edge of India plate, along the Himalaya Range Front, active deformation extends through Tibet and into China, Mongolia, and as far north as Russia. Along the eastern flank the subduction of the Indian plate under the Burma plate in the Andaman-Nicobar Islands region. To the south the transition between the India plate and the Australian plate is uncertain as seismicity is dispersed over thousands of kilometers and shows no distinct trends that highlight an obviously distinct boundary. Along the western plate boundary, the Central Indian Ridge, the Carlsberg Ridge and Owen Fracture zone discretely separate Indian plate from the Somalian and Arabian plates through a series of spreading centers and transform faults.

Studies of global reconstructions phenomena have suggested that the Indian plate move at a rate of 54 mm/yr (0.054 m/yr) and hence leading to convergence with the Asian plate (DeMets et al., 1994). The interior of Indian tectonic plate have Himalayan mountain belt, Indo-Burmese range, peninsular shield, and Sindhu-Ganga-Brahmaputra alluvial plains.

Fig(1): Indian Tectonic Plate



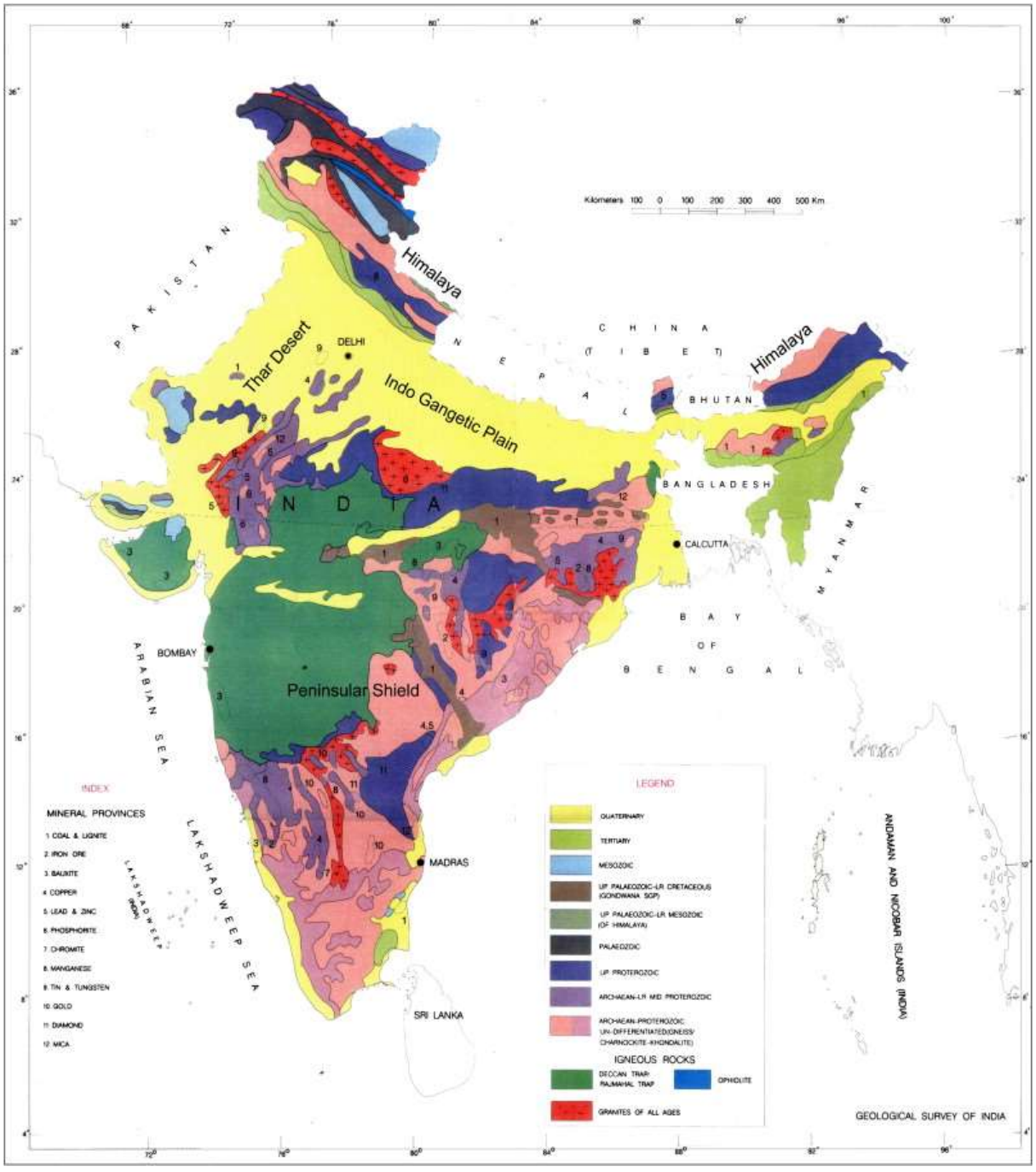
Source: Venkata Dilip Kumar Pasupuleti and Pradeep Kumar Ramancharla.
(International Journal of Advanced Earth Science and Engineering)

Geological structure & physiographic structure of major land masses of Indian continent:

The most silent fact with consider to both the physiography and geology of the Indian region is that it is calm of three different earth-features, which are as contrasting in their physical as in their geological characters. These three divisions are:

1. **The triangular plateau of the Peninsula**, with the island of Ceylon.
2. **The mountainous region** which borders India to the west, north, and east, including the countries of Afghanistan, Baluchistan, and the hill-tracts of Burma, known as the extra-Peninsula.
3. **The great Indo-Genetic Plain** of the Punjab and Bengal, separating the two former areas, and extending from the valley of the Indus in Sind to that of Brahmaputra in Assam.

Fig(2): Geological Map of India



Source: Published Map by GSI Govt. of India.

As mentioned above, the Peninsula, as an earth-feature, is entirely unlike the extra-Peninsula. The following differences the main points of divergence between these two regions:

Stratigraphic: Connected with the geological history of the areas. Ever since the Cambrian period, the Peninsula has been a land area, a continental fragment of the earth's surface, which since that epoch in earth-history has never been submerged beneath the sea, except temporarily and locally. No considerable marine

sediment of later age than Cambrian was ever deposited in the interior of this land-mass. The extra-Peninsula, on the other hand, has been a region which has lain under the sea for the greater part of its history, and has been covered by successive marine deposits of all the great geological periods, commencing with the earliest, Cambrian.

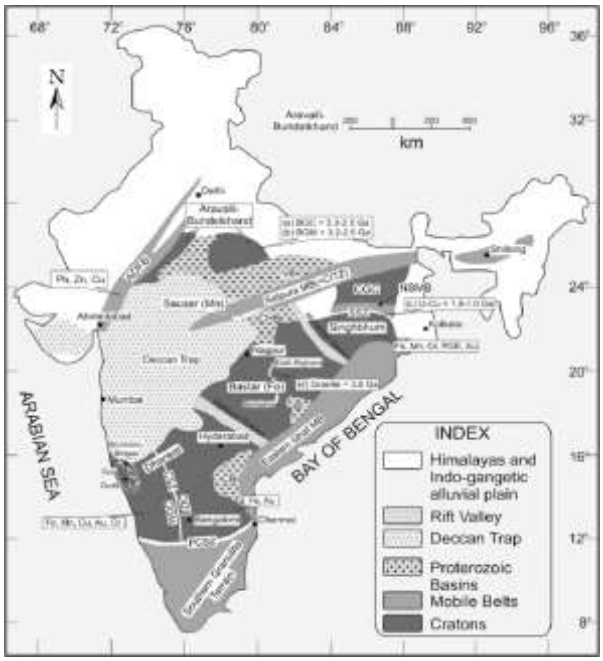
Geotectonic: Pertaining to the geological structure of the two regions. The Peninsula of India reveals quite a different type of architecture of the earth's crust from that shown by the extra-Peninsula.

Peninsular India is a segment of the earth's outer shell that is composed in great part of generally horizontally reposing rock beds that stand firm and immovable upon a deep-seated foundation and that have, for an immense number of ages, remained so impassive and undisturbed amid all the revolutions that have again and again changed the face of the earth. Lateral thrusts and mountain-building forces have had but little effect in folding or displacing its originally horizontal strata.

The extra-Peninsula, on the contrary, is a portion of what appears to have been a comparatively weak and flexible portion of the crust that has undergone a great deal of crustal deformation. Rock-folds, faults, thrust-planes, and other evidences of movements within the earth are observed in this region on an extensive scale, and they point to its being a portion of the earth that has undergone, at a late geological epoch, an enormous amount of compression and upheaval. The strata everywhere show high angles of dip, a closely packed system of folds, and other violent departures from their original primitive structure.

Physiography: The difference in the external or surface relief of Peninsular and extra-Peninsular India arises out of the two above-mentioned differences, as a direct consequence.

Fig(1): Geological structure and physiography of Indian sub continent



Source: Published Map of GSI Govt. of India.

In the **Peninsula**, the mountains are mostly of the “Relief " type, i.e. they are not mountains in the true sense of the term, but are mere outstanding portions of the old plateau of the Peninsula that have escaped, for one reason or another, the weathering of ages that has cut out all the surrounding parts of the land; they are, so to say, huge " tors " or blocks of the old plateau. Its rivers have flat, shallow valleys, with low imperceptible gradients, because of their channels having approached to the base level of erosion. Contrasted with these, the mountains of the other area are all true mountains, being what are called “tectonic " mountains, i.e. those which owe their origin to a distinct uplift in the earth's crust and, as a consequence, have their strike, or hue of extension, more or less conformable to the axis of that uplift. The rivers of this area are rapid torrential streams, which are still in a very immature stage of river development, and are continuously at work in cutting down the inequalities in their courses and degrading or lowering their channels. Their eroding

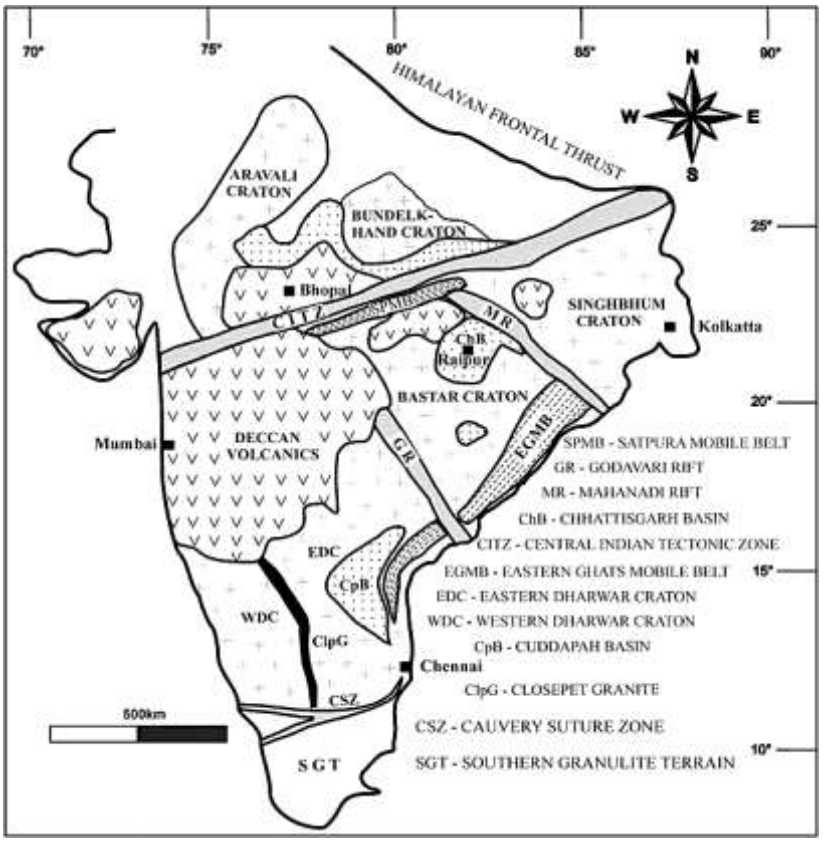
powers are always active, and they have cut deep gorges and precipitous canons, several thousands of feet in depth, through the mountain in the mountainous part of their track. .

The type of crust segments of which the Peninsula is an example, is known as a Horst—a, solid crust-block which has remained a stable land-mass of great rigidity, and by these has been unaffected by any folding movement generated within the earth during the later geological periods. The only structural disturbances to which these parts have been susceptible are of the nature of vertical, downward or upward, movements of large segments within it, between vertical (radial) fissures or faults. The Peninsula has often experienced this "block-movement" at various periods of its history, most notably during the Gondwana- period.

The earth-movements characteristic of the flexible, more yielding type of the crust, of which the **extra-Peninsula** is an example, are of the nature of lateral (i.e. tangential) thrusts which result in the wrinkling and folding of more or less linear zones of the earth's surface into a mountain-chain (orogenic movements). These movements, though they may affect a large surface area, are solely confined to the more superficial parts of the crust, and are not as deep-seated as the former class of movement's characteristic of horsts.

The third division of India, the great **alluvial plains** of the Ganges, though, humanly speaking, of the greatest interest and importance, as being the principal theatre of Indian history, is, geologically speaking, the least interesting part of India. In the geological history of India they are only the annals of yester-year, being the alluvial deposits of the rivers of the Indo-Ganges systems, borne down from the Himalayas and deposited at their foot. They have covered up, underneath a deep mantle of river-clays and silts, valuable records of past ages, which might have thrown much light on the physical history of the Peninsular and the Himalayan areas, and revealed their former connection with each other. These planes were originally a deep depression or furrow lying between the Peninsula and the mountain-region.

Fig(4): Major Land Masses of Indian Sub Continent



Source: Published Map of GSI Govt. of India

Scenario of Indian Plate movement:

Until roughly 140 million years ago, the Indian Plate formed part of the supercontinent Gondwana together with modern Africa, Australia, Antarctica, and South America. Gondwana broke up as these continents drifted apart at different velocities, a process which led to the opening of the Indian Ocean.

In the late Cretaceous, approximately 100 million years ago and subsequent to the splitting off from Gondwana of conjoined Madagascar and India, the Indian Plate split from Madagascar. It began moving north, at about 20 centimeters (7.9 in) per year, and is believed to have begun colliding with Asia as early as 55 million years ago, in the Eocene epoch of the Cenozoic. However, some authors suggest that the collision between India and Eurasia occurred much later, around 35 million years ago. If the collision occurred between 55 and 50 Mya, the Indian Plate would have covered a distance of 3,000 to 2,000 kilometers (1,900 to 1,200 mi), moving faster than any other known plate.

In 2012, paleomagnetic data from the Greater Himalaya was used to propose two collisions to reconcile the discrepancy between the amount of crustal shortening in the Himalaya (~1300 km) and the amount of convergence between India and Asia (~3600 km). The continental fragment of northern Gondwana rifted from India, traveled northward, and initiated the "soft collision" between the Greater Himalaya and Asia at ~50 Ma. This was followed by the "hard collision" between India and Asia occurred at ~25 Ma. Seduction of the resulting ocean basin that formed between the Greater Himalayan fragment and India explains the apparent discrepancy between the crustal shortening estimates in the Himalaya and paleomagnetic data from India and Asia.

In 2007, German geologists suggested that the reason the Indian Plate moved so quickly is that it is only half as thick (100 kilometers or 62 miles) as the other plates which formerly constituted Gondwana. The mantle plume that once broke up Gondwana might also have melted the lower part of the Indian subcontinent, which allowed it to move both faster and further than the other parts. The remains of this plume today form the Marion Hotspot (Prince Edward Islands), the Kerguelen hotspot, and the Reunion hotspots. As India moved north, it is possible that the thickness of the Indian plate degenerated further as it passed over the hotspots and magmatic extrusions associated with the Deccan and Rajmahal Traps. The massive amounts of volcanic gases released during the passage of the Indian Plate over the hotspots have been theorized to have played a role in the Cretaceous–Paleocene extinction event, generally held to be due to a large asteroid impact.

The collision with the Eurasian Plate along the boundary between India and Nepal formed the orogenic belt that created the Tibetan Plateau and the Himalaya Mountains, as sediment bunched up like earth before a plow.

The Indian Plate is currently moving north-east at 5 centimeters (2.0 in) per year, while the Eurasian Plate is moving north at only 2 centimeters (0.79 in) per year. This is causing the Eurasian Plate to deform, and the Indian Plate to compress at a rate of 4 millimeters (0.16 in) per year.

Indian Interplate Deformation and Indian Stable Shield:

The Indian shield region consists of various complex rift zones and several shear/thrust zones. Indian shield region is categorized as Stable Continental Region (SCR). However, Indian shield region has witnessed several earthquakes of magnitude six or more since 18th Century, some of which were disastrous (Bhatia et al., 1999). The spatial distributions of earthquakes of magnitude 6 and above are shown in the Figure 6 (c). This Intraplate seismicity exits across Central India that might be related to flexure of the plate as it is thrust below Tibet (Bilham et al., 2003).

The Narmada-Son Lineament (NSL) is one of the significant tectonic features of the Indian shield trending ENE-WSW apparently dividing the shield into two sectors, namely northern and southern sectors (Bhatia et al., 1999). This paleo-rift zone (Jain et al., 1995) exhibits high heat levels and strain rates estimated from seismicity that are larger than many stable continental regions (Rao, 2000). This suggests a potential concentration of intraplate deformation or kinematic separation of India into two distinct plates. Thinned and weakened lithosphere formed due to passive-margin normal faulting in the Cretaceous might also have led to the increased seismicity activity in the region (Biswas et al., 2007) and by heating from the plume head is

the reason for the late Cretaceous Deccan flood basalts (Chandrasekhar et al., 2009). Ductile creeps occurring at depths from 10 km to 15 km leading to continental flexure, which is a major factor for intraplate tectonism. 285 earthquakes have occurred in the last forty years with varied magnitudes at different focal depths, of which 200 earthquakes have occurred majorly at the focal depths of range between 10 km to 15 km over Indian stable shield (Koyna, Killari and Bhuj earthquakes) (Khan, 2009).

Conclusion:

As mentioned above estimated that the peninsular plateau or the south Indian craton is most formational striking power and strength of Indian plate due to their segment of the earth's outer shell that is composed in great part of generally horizontal reposing rock beds that stand firm and immovable upon a deep-seated foundation and that have, for an immense number of ages, remained so impassive and undisturbed amid all the revolutions that have again and again changed the face of the earth. Lateral thrusts and mountain-building forces have had but little effect in folding or displacing its originally horizontal strata. The origin and formation of alluvial plains of the Ganges they play a role of plate which displaced vertically and developed in Rift valley as the activation of high eperogenitic movement during the several years. And this vertical upliftment also revealed the increasing height of the Himalayas. In this case the dynamic tectonic engine activated as a Strike-slip system. Though after several years ago highly activation of eperogenitic force developed the fault scrape, the south Indian craton will separate from the mountainous region as per the respective tract.

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