Trans.Inst.Indian Geographers
ISSN 0970-9851

Geomorphological Regionalisation of India

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Three Divisions

India is a conglomeration of several geomorphological regions. *Regions here* are natural divisions, where several parts are 'involved in a common history by which the present physiographic features' (Powell, 1895) have been developed. In India, such natural divisions are primarily the Peninsula, the Plains and the Himalayas. The time span of' 'common history' is, however, different in each of these. In a sense, India as a whole is a natural division, bordered by High Asia and the oceans. A fourth natural division, that of coasts, is dwarfed by the Peninsula reaching out to the shelves, where the current eastern tilt is attested by an unequal width on the west and on the east. The Peninsula, again, reaches out in the north below the Plains to the Himalayas, as is now confirmed by geophysics.

Geophysics, again, indicates a foredeep south of the Himalayas. This foredeep is narrower than the Plains and has a 'common history' with a time span, longer than that of the plains. That India itself is a 'region' and consists of several component 'regions' points towards a *hierarchy* of regions with a 'common history', differing at every level. It is so, as the factor dominant at one level ceases to be so at the next. This is illustrated from a drainage basin in the classic paper of Schumm and Lichty (1965) and is accepted as a generalising principle in a Table by Fairbridge (1968, p. 622), prompted by Jan Tricart. This principle was adopted in 1972, while formulating a post-graduate course in Jawaharlal Nehru University, New Delhi. The assumption was that with decreasing space size at the lower hierarchical level the time span of 'common history' would also be shorter. That it is not always observed became apparent very soon, as the 'factor' for regionalisation gets refined with the change of *scale* and does not yield to another without a proper confrontation. This is amply borne out in the account below.

Tectonics is the dominant factor, identified at the *level* of macro-regions. It acts on an initial surface and is substituted by rock strength (geology) at the next level of 'meso-regions, where dominance is equally sought after by climate. Next comes the drainage basin up to the level of micro-regions, where other factors locally vie with hydrology. But when tectonics acts locally through plate movement, it alters the placid hierarchy of factors. So also climate operating as a 'system' can claim primacy at the level of macro-regions and higher, as is indicated by 'monsoons' characterizing now the 'common history' almost of entire India as much as the tectonic 'shield'.

Peninsula

Indian Peninsula grew around several centres, that are the *'continental nuclei'*. In late nineteenth century Phillip Lake (1893) surmised this and in the last century it was revived by Bose (1961). But only with geochronology making rapid strides and the publication of B. P. Radhakrishna in 1989 on 'suspect tectonostratigraphic terrain elements' this continental accretion gained wide recognition here in spite of the heyday of plates. Dharwar (Gorur) and Goa (Anmod' Ghat) were the southern nuclei, Bastar (Markampara) and Singbhum (Bonai) the middle ones, while Bundelkhand (Baghora) and Rajasthan (Jhamar Kotra) the northern ones. In each case the oldest rock is around the nuclei and younger basement belts girdled them almost in the fashion of a Roman amphitheatre.

The nuclei are of comparable *size* with Bundelkhand a bit larger. This conforms to the pattern in Africa and South America, where the southeastern seaboard shows nuclei of Indian proportions and the northern ones (Angola, Nubia, Amazon) are somewhat closer to Bundelkhand in size. West Australia shows nuclei of Indian size, while in East Australia, those are larger. It should be noted that North America has only one continental nucleus and Europe, two.

South of the Palghat gap in the Indian Peninsula there are no nuclei. Nor are they evident in the Jodhpur block, west of Aravalli. In the northeast, Sonapahar throws up old rocks but without any girdle around. Presumably this has resulted from erosion on recent tectonic upheaval of a wedge of the Singbhum block. In case of the west, StiIle (1955) visualised Assyntian folding unique in India. In the south, Pan-African folding takes over from the girdles north of Palghat. The lineament there separates a crustal thickness of 36 km in the north and 45 km in the south (Mahadevan, 1995).

The *ages* of the Indian nuclei are nearly the same, around 3.5 Babp. Bundelkhand is younger and Singbhum, the older with Eastern Ghats yielding the oldest rocks in India. The basement grew outward from the nuclei through younger and younger belts. At the points the belts from two nuclei merged, the *boundary* of the regions emerged, first between Singbhum and Bastar before the one between Bastar and Dharwar. The one within Dharwar is concealed under the *cover* of the Deccan Trap, which extends north up to Bundelkhand and also touched Singbhum in its west. Rajmahal Trap cover is restricted to east Singbhum within the Gondwana sedimentaries, that provided the boundary also between Singbhum and Bastar roughly along the present Mahanadi river course and between Bastar and Dharwar along the present Godavari river. No substantial marine Phanerozoic cover is found east of Aravalli in the Peninsula. This defines the Gondwana Land of Suess (Chandra, 1996). Bundelkhand region with a wide sedimentary cover has a southern boundary along the Narmada-Son Line (West, 1962) and a western one along the Aravalli. The sedimentary cover in this region gets younger towards the continental nucleus unlike the belts of the basement, that are younger away from it. The boundary between the region around Bundelkhand and around JhamarKotra in Rajasthan is concealed under the sedimentary cover of the Vindhyans. The boundaries here are radically different. The one in the south

is a narrow and sharp *plate boundary,* 1.4 Babp old, while that in the west is broad and diffuse (Gordon, 1998) and much younger. To its west there is much marine Phanerozoic cover. So also in the region to the east of Singbhum, but the cover there is mostly post-Rajmahal in age.

If the western boundary west of Aravalli in the Jodhpur block is visualised at times as the boundary with 'Indo-Africa', the southern boundary of Dharwar is claimed as totally African, displacing some Gondwana fragment, which then moved west to Natal and, may be, even to Patagonia through horizontal translation. This is indicated also by the marine erosion map of Strakhov (1962), reproduced in Chandra (2001), that shows the Patagonia tail missing in the south of South America. The horizontal movement seems to have respected deep crustal, boundaries in the south of the Indian Peninsula, shown in the relic off West Australia. This would explain much of the palaeobiogeographic riddle at the end of the Cretaceous, that primarily launched the idea of Gondwana as a 'continuous continent'.

Cover geology provides the 'meso-regions' in the Peninsula, where together with the basement the geological 'rock cycle' conforms to the 'macro-region'. Recent *tilt* to the east encompasses Singbhum and the sedimentation in its east underlines it (Evans, 1971), while west of Aravalli the tilt to the west is maintained. This results in a cymatogenic upwarp east of Aravalli.

Geomorphological regionalisation of the Indian Peninsula is echoed in the *economic geological regionalisation* there. Gold is found in all the continental nuclei, but never of the Rand Type that resulted from prolonged erosion. Diamond at the boundaries of macro-regions in the Peninsula benefited just from such erosion with Golconda leading the way. Many belts in close proximity with marine rocks around 2 Babp brought in an iron-manganese bonanza, as the chemistry of seawater changed at that time. But the paucity of the Phanerozoic marine cover meant scanty oil-gas, except east of Singbhum and west of Aravalli. The Gondwana cover brought in coal. No marked orogeny in the continental nuclear regions meant a scarcity of base metals and silver. In a broad sweep, the economic geological regionalisation defined the *Dunn Line* through Amarkantak (Chandra, 1987).

Plains

Geomorphological regionalisation of the Indian Plains was a non-starter for long, as they are almost featureless except for the drainage basins. Hydrology vied there with the climate. But recently, shots in the third dimension has brought important dividends. Subsurface drilling for groundwater helped in drawing a *geomorphic map* east of Aravalli (Singh, 1996: Fig. 17), that shows a 465 Km long Sharda (Sarayu) megafan in the centre stage complete with a river channel, river valley terraces and upland terraces, going 'wild' in the past. West of it, Ganga with a river channel and terraces is never more than 30 km wide. It accesses the Sarayu upland terrace within about 300 km from its own megafan, combined with that of Yamuna, that is only 110 km long.

Pascoe (1950-1975: p.23) considered Yamuna, and not Ganga, the Main river now in the Plains, as the former runs in a deeper

channel up to Allahabad. Any student of river basin morphology would immediately end Ganga at Allahabad. Wilhelmy (1969) in his remote-sensed map seems to concur with this, though his stress was on the plains west of Aravalli. There lndus now flows *along* the tectonic trough, a foredeep of the Suleiman Range. East of it, the rivers including Ganga all flow *across* the tectonic trough in the foredeep of the Himalayas. East of Sarayu, this pattern is continued by Gandak, Kosi and Mahananda to define a *third* region. Then comes the breach of Rajmahal Trap basalt at around 76 kabp and the western rivers had easy access to the Delta. Brahmaputra-Meghna flowed along the tectonic troughs to produce a huge thickness of sediments much before the emergence of large rivers, west of Rajmahal.

The surface of the Ice Age Earth (McIntyre et al, 1976) shows only short streams in a savanna, west of Rajmahal and the first large river to gush in there was Sarayu after 6 Kabp, a millennium earlier than Yamuna and Ganga. Rivers east of Sarayu (Ghaghra) in the third region are much more *recent*. They grow wild at times, though the scale is more modest than the erstwhile Sarayu, which is now subdued enough to produce only a 110 km megafan and curves east in the south to meet the combined course of Yamuna and Ganga, after Gomati but before Gandak.

West of Aravalli, *the meso-regions* on the basis of regional geology are in tune with that of climate and hydrology plays a subordinate role. Then comes the Indian Desert with dunes and saline lakes like Sambhar and Didwana.

The *coastal plains* in south India also show Teri dunes and monazite placers on two sides of the southern tip. Further north in the west, we have the Rann and the *estuaries* of large rivers like Narmada. In the east, we have the Chilka lagoon and the coastal dunes of Digha. Aided by climate in these *micro-regions*, we have laterites at Bhuvaneshwar and at Nanur. On the east coast we have deltas of Mahanadi, Godavari and Kaveri.

Peninsular large rivers like Chambal, Son, Mahanadi, Godavari, Kaveri are all *rain-fed* with no megafans, while north of the Peninsula almost all large rivers are glacier-fed. Yamuna of Delhi, Gomati and 'tributaries' from the right bank as Damodar and Ajay to the combined course of rivers Yamuna to Kosi before Rajmahal are, however, presumed to be rain-fed. Yamuna west of the Yamunanagar Falls is considered to be glacier-fed. Yamuna is the closest to Aravalli, flowing along its foredeep just like lndus west of Aravalli flows along another foredeep. West of Aravalli, the large rivers —the Harappan, the Epic Saraswati and the Ghaggar at different time intervals are considered as rain-fed as also Luni, that does not reach the sea. East of them, most others are *glacier-fed,* linked to a deglaciation history of the Himalayas.

Himalayas

Regionalisation of the Himalayas preceded that of other divisions by several decades. *East-West Lines* along the Main Boundary Fault, the Main Central Thrust and the ophiolite line in the lndus Suture north of it separated the regions (Lesser Himalayas, Greater Himalayas, Main Himalayas, High Himalayas etc). This regionalisation

has acquired the primacy in the plate considerations, that insist on ascribing even any strong earthquake in the Peninsula (Monghyr, Latur) to a plate push along such lines, adversely affecting India's relation with its crustal neighbours. Geologists with long experience in Himalayan traverses resent this (Auden, 1981).

The resentment is reflected in another set of regionalisation with North-South boundaries, that stress sectors like Northwest, Central, Northeast (Petrushevsky, 1971). This *sectoral* division is played down in Plate Tectonics, but it gains prominence in *Neotectonics*, which, it has to be emphasised, is older than Holocene. The time range of Neotectonics is restricted by definition to 'Late Tertiary (35 Mabp) and Early Quaternary vertical crustal movements' (Beckinsale and Chorley, 1991: p. 171). Himalayas are also characterised by sectoral deglaciation (Sharma and Owen, 1996) and related isostatic rebound. Himalayas, unlike Alps with folded belts, is a Neotectonic mountain (Chandra, 1995). On both sides in the west and the east they are flanked by folded belts in the Suleiman Range and the Naga-Lushai Hills.

There is no sign of any sectoral *deglaciation* north of the Himalayas, making *Indo-Brahm* a non-starter. In the south too this holds for any Siwalik River, as also there was no 'Gondwana' River in the Peninsula along the troughs. Everywhere north of the Himalayas deglaciation started uniformly around 18 Kabp and in the southern foothills around 3 Kabp. In between, deglaciation characterised first the Northwest sector, then around Gurla Mandhata and Gangotri in the Central at the end of the Bhagirathi Glacial (63 Kabp to 6 Kabp) before moving east to the Northeast up to 0.5 Kabp. The 'longitudinal' streams with their courses along the structural grains are confined west of Gurla Mandhata, initiating, according to Pascoe (1950-1975: p.21) even Sutlej in this category. But recent remote sensed maps restrict Sutlej to west of Aravalli and at Gurla Mandhata a longitudinal glacier starts the Vedic Sarasvati instead. The 'transverse' glacier there starts Sarayu. West of it, the 'longitudinal' Bhagirathi at Gangotri is paired with the 'transverse' Alaknanda. Further west, the dominant 'longitudinal' turns into 'transverse' on meeting Siwalik strata before the *gorges* north of the foothills. The gorges mark the Himalayan stretch from lndus to Subansiri with the remarkable exception of the Vedic Sarasvati that ends up without meeting the Siwalik strata.

The 'molasse' of the *Siwaliks*, resulting from a non-synchronous elevation in their northern provenance showed a thick tripartite stratigraphic subdivision in the Northwest, a bipartite one in the Central and a single unit in the Northeast (Chandra, 1988). The inheritance of such sectoral differentiation can be sensed also from the Gondwana stratigraphy, albeit lower stratigraphic units there thicken in an opposite direction — tripartite in the east and a single unit in the west.

When the Himalayas merge in southeast with Naga-Lushai Hills, Siwaliks again thicken in the oil-producing foredeep before the *Delta,* that fans out to the Mahananda Fault east of Rajmahal and to the Bay of Bengal. In the process the Delta overrides the Peninsular wedge from Singbhum and confronts the western estuary of Bhagirathi. The Himalayan sediments do not seem to have produced much impact on the Delta

till much later in time than the neotectonic period. The Delta started accreting around 80 Kabp (Dasgupta, 1997). With the Mean Sea Level falling in the Ice Age, the Delta seems to have reached the Andamans but with no drop from Gangotri ever there.

A case for a large-scale horizontal movement by distancing the Himalayas from the Indian Peninsula is presented by the palaeobiogeographic riddle in the Pre-Carboniferous (Reed, 1910). Burma then shared some fauna with the Baltic Europe, bypassing the Himalayas, where Spiti shows a strong connection instead with British Columbia in the northwestern parts of North America. The replica of the western coast of North America, as shown on the Pacific floor, is faithfully copied by the arcuate curves north of the Himalayas. The palaeobiogeographic riddle in the Pre-Carboniferous strengthens also the sectoral regionalisation and a sea passage north of the Narmada-Son Line in the Pre-Gondwana days. In the relic off West Australia there are no Himalayas.

Concluding Remarks

A catapult now provides some tension through the Amarkantak knot (Chandra, 1987) to all the three divisions. While it holds, the geomorphological region of India can be conceived as consisting of three 'first-order regions' (Peninsula, Plains and Himalayas). In their turn, they consist of several 'macro-regions' in each (six in the Peninsula, five in the Plains and four in the Himalayas) with component 'meso-regions' and even 'micro-regions'. The exact number and extent of each continues to be in some flux.

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