Geological marvels, hallowed shrines and unification of people of India

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Spectacular landforms and extraordinary geological features sculptured by uncommon earth processes occur in different parts of the Indian subcontinent. Presumably, unable to unravel the mysteries of their origin, and realizing that singularly odd features located in picturesque places attract believers and non-believers alike, the leading lights of the society of ancient India invested them with the aura of divinity and established shrines of the commonly venerated deity. Influencing people belonging to diverse racial-ethnic groups inhabiting different parts of the country, speaking languages belonging to disparate groups, indulging in different socio-cultural practices and eating and dressing differently, to go on regular visits to these hallowed sites or seats of deity, the visionary sages and seers of the ancient India endeavoured successfully to promote interactions of visitors to these geological marvels located in different parts of the country and bring about cross-fertilization of thoughts and cultural elements, and thus the unification of the largest section of the population.

Keywords:

SINGULARLY spectacular landforms and extraordinary geological features formed by uncommon earth processes may be called geological marvels, documenting memories of events of great moments that happened in the past. They evoke not only awe and admiration of discerning naturalists including earth scientists, but also fire imagination of perceptive people who ponder on evolution of landforms and on creation and the creator. They may also be called geoparks in the sense that they are geological heritages enhancing the geographical character of the places where they are located.

In the ancient times, the explorers, including wandering sages and saints, who travelled across greater India saw in the geological marvels more than what the earth scientists see. Presumably, unable to unravel the mystery of their origin and regarding them to be the nature's singular rather fantastic handiwork, they imparted to them an altogether new meaning by investing in them with the aura of divinity. To illustrate the point, consider the *Om Parvat* situated (30°11′56″ : 81°01′52″) not far from the India–Tibet–Nepāl trijunction to the west of the route to Kailās–Mānsarovar. Visible from Nābhidhāng, the 6191 m high peak in the Tethys Himālayan terrane is made up of fossiliferous Triassic–Jurassic rocks folded twice in a manner that the depressions within the arms of overturned folds are filled round-the-year with ice and snow, giving rise incredibly to a figure stunningly similar to the letter 'om' (ॐ), with even a dot atop (Figure 1). Nature seems to have crafted the letter 'om' in all its perfection! How can one not be impressed, if not awed, by this geological marvel. Another example is Amarnath, the exquisitely spectacular ice stalagmite resembling a *Lingam* in a cave within the Triassic limestones in the Kashmir Himalaya. It is therefore understandable that the wandering sages and saints (*rishi* and *maharshis*) of the ancient times who had identified the geological wonders or marvels in all parts of the country – in the north, south, west, east and many places across the country, regarded them as special creations of God – as His hallowed shrines. These have been described in the *Purānas* and the epic *Mahābhārat*, both authored by Krishna Dwaipāyan Vyās. The original *Purāna* was penned before the Mahābhārat War and the epic *Mahābhārat* sometime after that debilitating event[1]. The war occurred in 3478 BP (ref. 2), that is, approximately 3500 BP (ref. 3).

Visionary leaders of the society in the Purāna times recognized the geological marvels in different parts of the country and regarded or designated them (most of them) as holy shrines perhaps in an attempt to glorify their venerable icon or deity so that the devout, the credulous and the curious would flock to them. One may dismiss the *Purāna* and the epics such as *Mahābhārat* as works of fiction, but one cannot deny that the geological marvels regarded or designated as shrines are indeed located precisely where these ancient texts describe, the narratives perfectly matching with the reality.

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Hallowed geological marvels

Perusing the map (Figure 2) showing location of 12 *Jyotirling*[4] and a few other shrines established in the Purāna times, two facts emerge. (i) They are located in all parts of the Indian subcontinent – reaching out to all ethnic groups living in the country *Bhāratvarsh*. (ii) their situations happen to be of great geodynamic significance, particularly related to evolution of the Indian landmass[1]. The then leading lights of the society must have realized that only spectacular features, particularly if located in picturesque places, can attract people, even those who are non-believers or agnostics. The geological marvels or wonders were thus chosen as the seats (*dham*) (Figure 2) of, for example, the *Lingam* of Shiva, the then most venerable icon of the largest section of the population of India. Other important shrines such as Kailās and Amarkantak are also located in geomorphically and geologically singular places.

Himalayan province

Across the Himālaya in southwestern Tibet is situated the many splendoured *Mount Kailās*, a massif in the Ladākh-Gangdese Range. Its location is unique in many ways. (i) It is situated just north of the geological junction of the Indian and Asian plates, described as a zone of continental collision (Figure 3 *c*). Known as the Indus–Tsangpo Suture, it is a narrow belt of multiple deep thrust faults of great lateral dimension. It is indeed a zone formed by the docking and eventual welding together of northward moving Indian landmass with the Asian continent. As India persistently pressed hard against mainland Asia, the leading frontal edge of the Indian plate buckled up (Figure 3 *d*) giving rise to a huge dome-shaped anticlinal[5], and heavy dense ultrabasic material from the upper mantle beneath the crust was squeezed up and out and emplaced along the great tectonic divide[6]. (ii) The Tibetan crust was torn apart by the NW–SE trending Karakoram Fault, along which at present the Tibetan crust is extending eastwards[7]. (iii) Four great rivers originate from this dome-shaped crustal upwarp (Mount Kailās–Gurlā Māndhātā) and flow in four different directions – the Sindhu (Indus) flows northward, the Satluj (Shatadru) takes southwesterly course, the Saryu (Karnāli–Ghāgharā) descends southwards and the Brahmaputra (Tsāngpo) takes the easterly direction (Figure 3 *a*).

The Kailās massif is made up of 2000 m thick pile (Figure 3 *b*) of ungraded pebbly askosic sandstones and conglomerates intercalated with maroon shales[6]. Resting on the basement of granites, the Kailās sediments were laid down by a river that meandered sluggishly and alternately flowed swiftly as a braided system[8]. The shales of the same formation elsewhere in Ladākh contain fossils of 23 to 27 million year-old plants rosewood and palms[9] implying that the climate then was warm and moist and the terrain not higher than 2100 m above the sea level (compared to more than 5000 m at present). In the Sindhu valley in Ladākh, the same Kailās horizon has yielded remains of deer, goat, rodent, python-like snake[10] and small rhinoceritoid mammal *Juxia*[11]. All these facts indicate tremendous geodynamic-geomorphic changes that took place here.

Figure 1. Situated close to the India–Tibet–Nepāl trijunction – and south of Kailās – the Om Parvat rises 6191 m high in the Tethys Himālayan terrane. The ice deposited in the arms of overturned folds form a figure strikingly similar to the letter 'om' even with a perfect dot at the top.

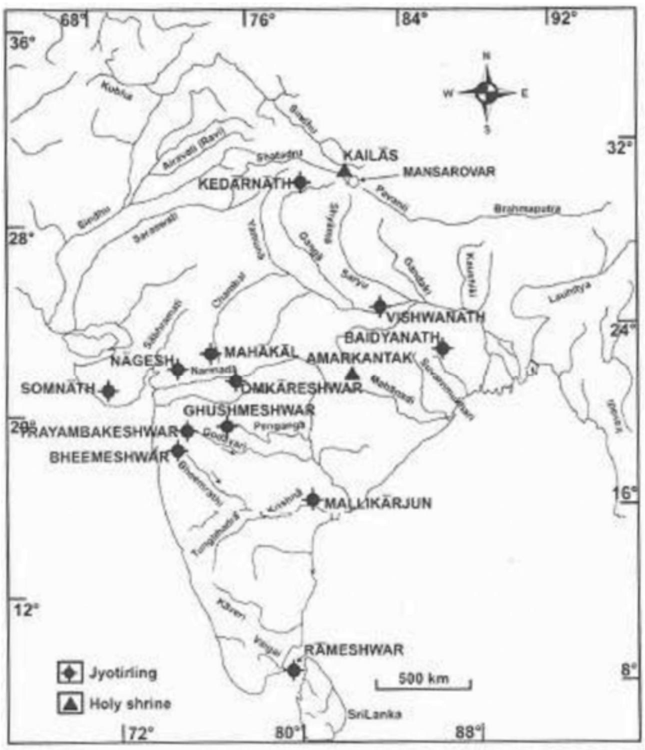

Figure 2. Location of 12 much venerated shrines in different parts of the greater India, (that is Bhāratvarsh) of the Purāna times. Twelve of them are *Jyotirling*, the *Shivalingam* described in the *Shiva Purān*[4] (from Valdiya)[1].

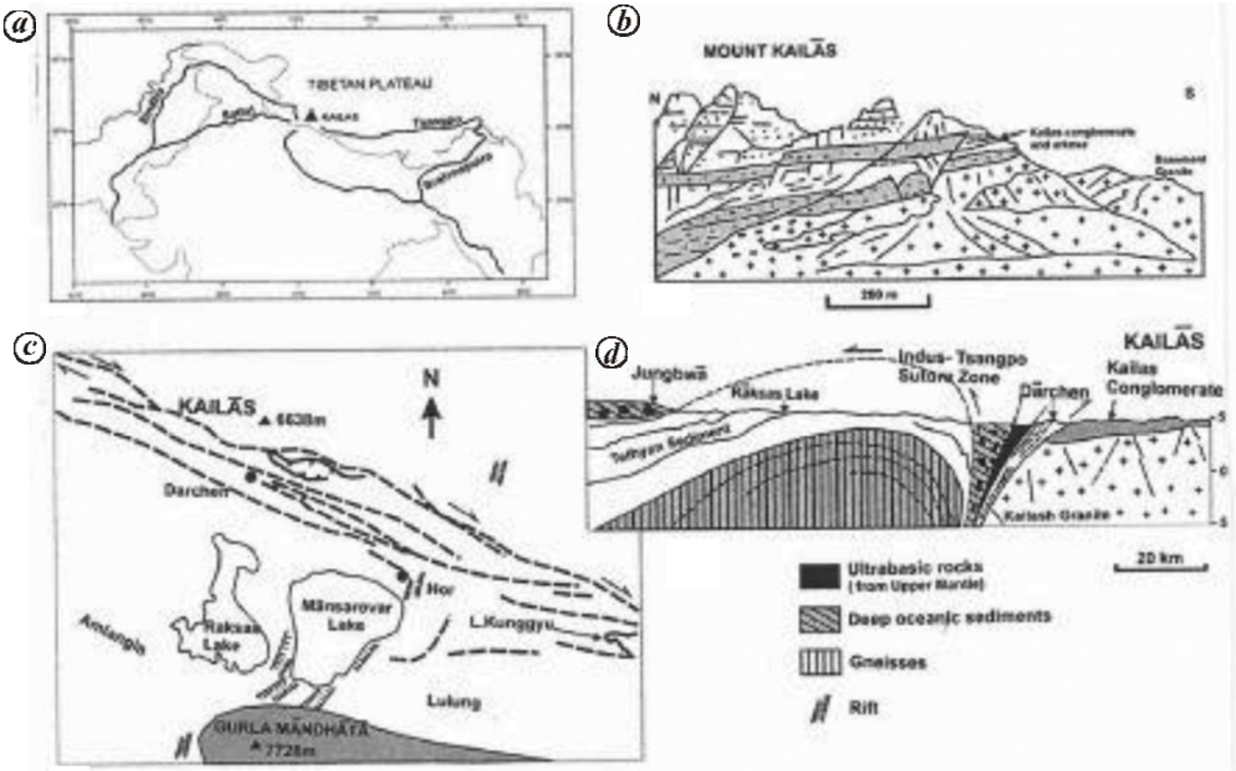

Figure. 3. ***a***, From the domal upwarp of the Kailās region emerge four great rivers – flowing in four different directions; ***b***, Huge pile of coarse-grained sediments (conglomerates and sandstones with shales) making the Mount Kailās, rest on the foundation of Kailās Granite belonging to the Ladākh–Gangdese Range, (after Heim and Gansser)[6]; ***c***, Mount Kailās sits in the proximity of great tectonic divide – the junction between the Indian landmass with the Asian plate, (after Laccasion *et al.*)[31]. ***d***, Along this junction or suture between two continents – the northward moving Indian plate buckled against the Asian continent, forming a huge domal upwarp (after Heim and Gansser)[6].

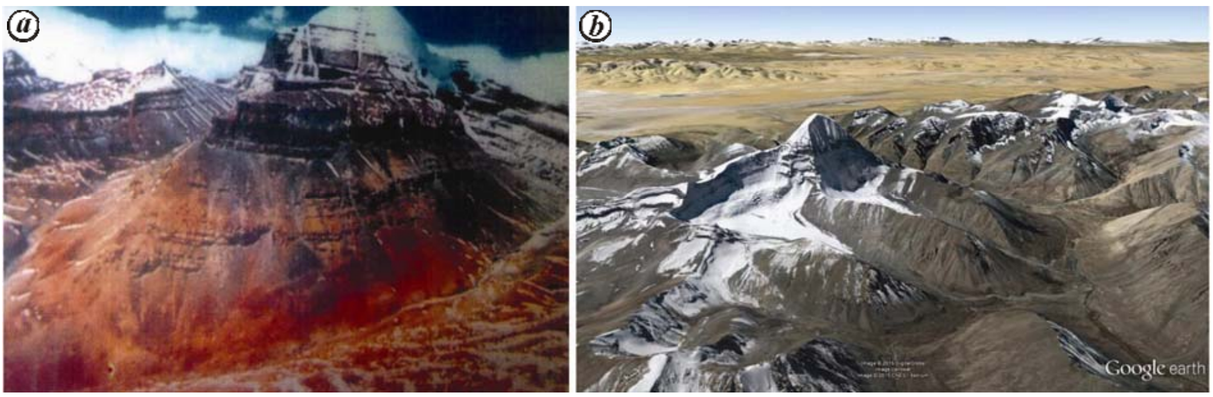

Figure 4. ***a***, Aerial photograph taken from the north brings out the *Lingam* in the centre surrounded by the circular depression with a ring of hills resembling *Yoni*; ***b***, Another view of the Kailās made up of the layered mass of sandstones and conglomerates resting on the foundation of granites. (Photo: Google Earth.)

A massif of exquisite splendour and beauty (Figure 4 *a* and *b*), Mount Kailās is regarded as the preferred abode of Shiva, the supremo or icon of the Kirāt tribes that inhabited the entire northern Himalaya. Although it is not included among the Jyotirlings, the Kailas shrine is nevertheless religiously visited year after year by thousands of devout Hindus, Jains and Buddhists as the holiest of the holy shrines in the Indian subcontinent.

A close look reveals that the Kailās resembles a stupendous Lingam surrounded by a circular depression with an outer rim of hills, the latter resembling the Yoni (Figure 4 *a*).

At the foot of the imposing 6940-m Kedārnāth peak and nestling in the picturesque amphitheatre-like glacial valley flows the Mandākini River (Figure 5 *a*). Not far downstream of the terminal moraine of the Chorabari

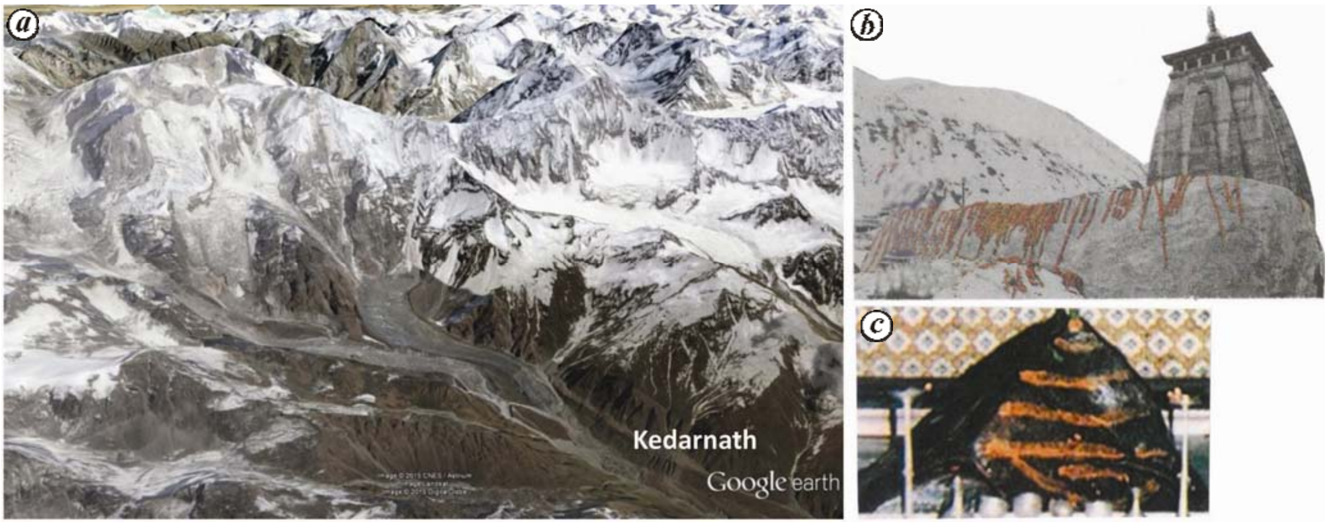

Figure 5. ***a***, Amphitheatre-like glacial valley of the Chorabari Glacier downstream of which behind a huge exotic block stands *Kedārnāth Jyotirling* (Picture: Google Earth); ***b***, Huge exotic block – piece of rock left behind by a retreating glacier – protected the celebrated temple of Kedārnāth against floods; ***c***, Glacial faceted piece venerated as Kedārnāth *Lingam*.

Glacier is located *Kedārnāth Jyotirling*. It is from the Chorabari Glacier that the Mandakini River emerges. The Mandakini is a tributary of the Ganga. The glacial valley is filled with the debris deposited by the glacier that has presently receded far behind the shrine. Among the moraines is a huge exotic block left behind by the retreating glacier (Figure 5 *b*). This exotic block protects the temple against floods and avalanches. In 2013, while the entire Kedārnāth township was wiped out by devastating flood, the temple of Kedārnāth remained unscathed because of the protective wall formed by this exotic block.

The mountain is made up of high-grade metamorphic rocks, penetrated by 20–22 million years old granite occurring as tabular sills of batholithic dimension and network of dykes and veins[12]. This is not an ordinary granite. It is an anatectic granitic characterized uncommonly by such metamorphic minerals as kyanite, sillimanite, garnet and cordierite. The anatectic granite formed as a result of differential and partial melting at high pressures and high temperatures of susceptible portions of material of high-grade metamorphic rocks. The molten granitic material pervasively penetrated layer-by-layer the gneisses and schists, giving rise to migmatite so intimately associated with the granite.

A glacier-faceted piece of rock left behind by the retreating glacier – an exotic piece – forms the Kedārnāth *Lingam* (Figure 5 *c*). Or maybe it is a block of anatectic granite fallen from the mountain peak and faceted by moving mass of the glacier.

Indo-Gangetic plains

The acclaimed and most celebrated *Vishwanāth Jyotirling* is located at Kāshi or Vārānasi on the left bank of the River Gangā. It was a great centre of learning and religious discourses in the ancient time. A close look at the map reveals that the consistently eastward-flowing Gangā abruptly swings northeastwards at Vārānasi and flows in that direction for about 100 km before resuming its easterly direction (Figure 6 *a*). The sharp swerving of the serenely flowing river implies that it was impelled to turn northeastwards. It turns out that a NE–SW trending fault that uplifted the Rāmnagar block to the east of the river (compared to the Vārānasi ground) is responsible for this drainage deflection[1].

The northeastward-flowing Gangā between Chunār in the south and Saīdpur (Buxur) in the north has a comparatively narrow floodway, not more than 3 to 8 km wide. In the Kāshi–Vārānasi area, the river's active channel is just a kilometre wide and confined within cliffs which continue almost up to Buxur[13]. Apart from the Gangā's narrow entrenched course, the telltale manifestation of neotectonic movement on this NE–SW fault is the 750 m long, 20 m high vertical cliff of the Rāmnagar area, developed on the right bank of the Gangā (Figure 6 *b*) – in the block east of the fault. Considerably affected by gully erosion, the cliff exposes many deformational structures such as reverse faults, fissures, folds and what look similar to soft-sediment liquefaction features[14]. All these features corroborate the surmise that the fault that deflected the Gangā in the Kāshi region is neotectonically active.

OSL dating of the sediments suggest tectonic movement 40 ka and 7 ka ago – the later event is supposed to be responsible for the uplift of the Rāmnagar block[14]. Significantly, the top 4 to 10 m sedimentary deposits contain cultural remains of the periods Northern Black Slipped Ware, dating back to the seventh–eighth century BC (ref. 15). Evidently, people lived in the Rāmnagar side of the Gangā some 3500 to 3000 years ago. It remains to be seen for how long the people have been living on the Kāshi–Vārānasi side of the river.

This fault is possibly the surface manifestation of the NNE–SSW trending transverse undersurface faults delimiting the underground hidden ridge of Precambrian rocks that lie under the very thick pile of sediments of the Ganga plain[16,17]. The fault is parallel to the subsurface Patna Fault, defining the hidden, undersurface Munger–Saharsā Ridge (Figure 7).

Vishwanāth Jyotirling thus sits in a place which has experienced impacts of recurrent neotectonism and attendant denudation drainage aberration.

Central India

The *Amarkantak* shrine (not a Jyotirling) in northern Chhattisgarh is located on the stupendous Mandla Lobe of the Deccan lavas represented by 1127 m high Maikal Range, a plateau delimited by high scarps. The shrine is the source of the River Narmadā, which not far from its origin tumbles down the high scarp in a series of waterfalls and cascades. The Mandla Lobe is made up of pahoehoe lavas characterized by ellipsoidal and spheriodal bodies resulting from a process in which balloon-like inflation in the mobile lavas played a dominant role[18,19].

West of Hoshangābād (Madhya Pradesh) is located *Omkāreshwar Jyotirling* on the southern bank of the Narmadā. Remarakably, at this spot, the Narmadā anomalously breaks into two branches, the southern channel being quite straight. Between the two channels is an elongate triangular island (Figure 8 *a*). The channels themselves have islands of sands. The bifurcation of the river suggests recent tectonic movement on presumably the WNW–ESE-oriented lineament. Along one of these oblique faults, the southern branch of the Narmadā has carved its remarkably straight course. The Narmadā, it may be pointed out, flows in a rift valley – an elongate depression formed due to sinking of the ground between two parallel or nearly parallel faults of Precambrian antiquity (Figure 9 inset). The rift is defined by ENE–WSW-oriented faults extending for several hundred kilometres across central India[20]. Significantly, it represents a great tectonic divide between northern and southern India[21].

The faults of the rift are quite active, the recent movement on which brought about drainage modification and landform changes[22]. It is suggested that the Satpurā has risen as a high range owing to movement in the later Quaternary time on the ENE–WSW southern faults of the continental divide[23]. This is further borne out by frequent earthquakes[24] that rocks the rift valley (Figure 9).

It should be obvious that Omkāreshwar sits in a place on the great tectonic divide between northern and southern

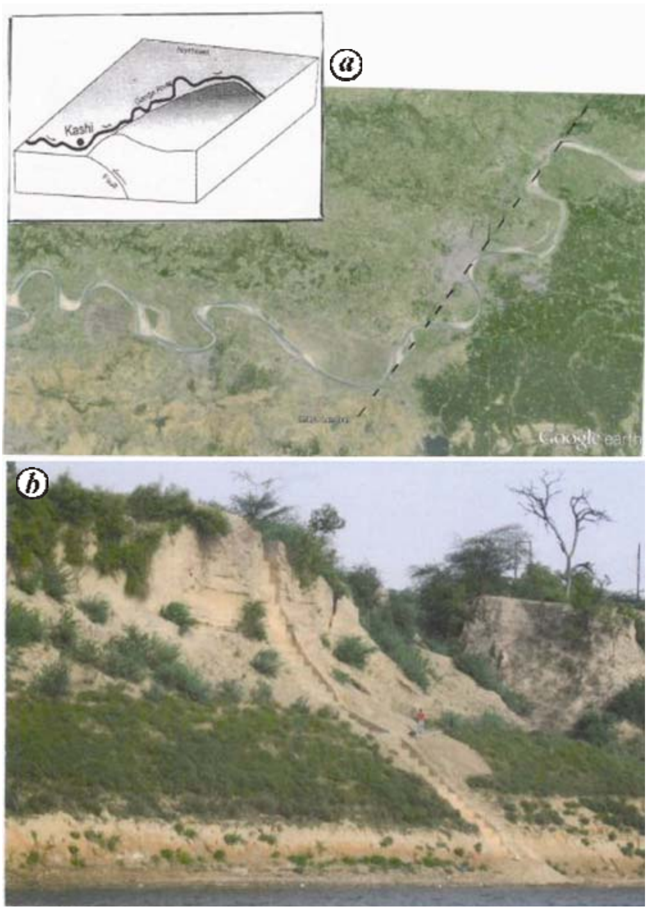

Figure 6. ***a***, Kāshi (Vārānasi) hosting *Vishwanāth Jyotirling* is situated at the point where the consistently eastward flowing Gangā abruptly swings northeastward (photo: Google Earth); (inset) Diagrammatic sketch shows how the uplifted Rāmnagar block resulting from movement on the NE–SW trending fault propelled the Gangā to flow northeastwards. ***b***, Uplifted Ramnagar terrace, exploring the fluvial sediments to gully erosion (Photo by Umakant Shukla, BHU, Varanasi).

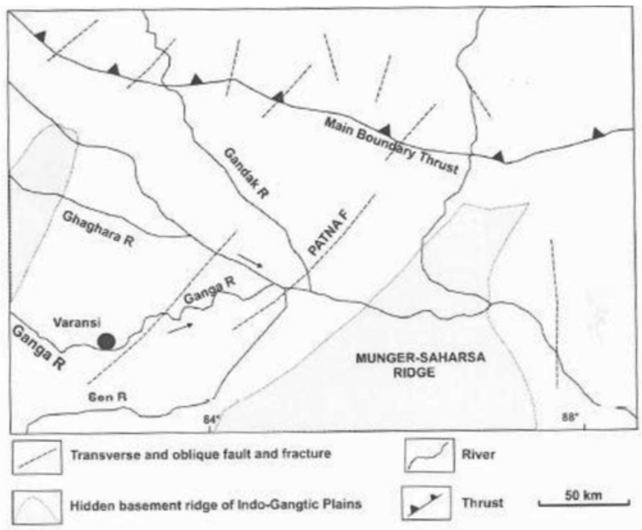

Figure 7. Underneath the thick pile of the Gangā sediments, there are hidden subsurface ridges and transverse faults, some of them quite active (From Valdiya).

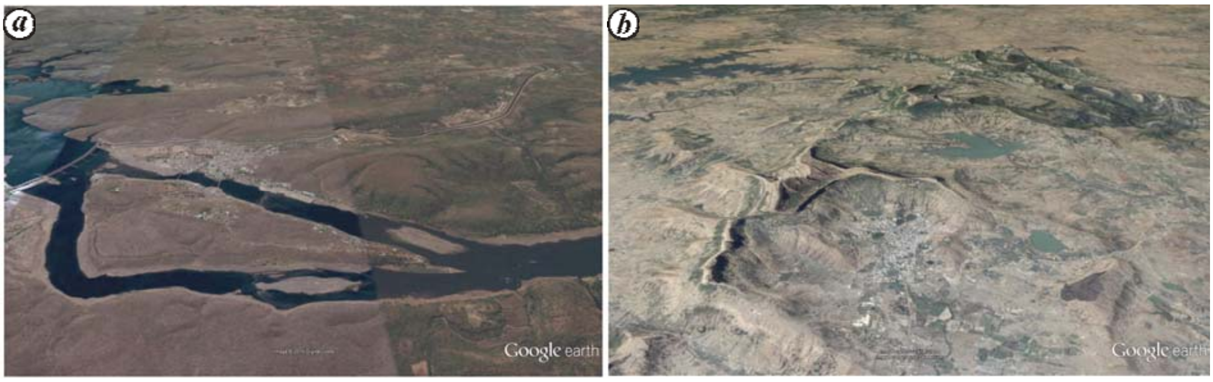

Figure 8. ***a***, At the spot where the Narmadā splits into two branches is located the holy shrine *Omkāreshwar Jyotirling*. The southern branch is a remarkably straight channel, presumably developed along a WNW–ESE trending active fault of later generation. Note the islands of sands within channels (View from North: Google Earth). ***b***, Three spectacular lava lobes make what looks similar to a *Trishūl* (trident) – the weapon that Shiva wielded. Within the two *shūls* or blades of the trident is the source of the Godavari River. (View from North: Google Earth).

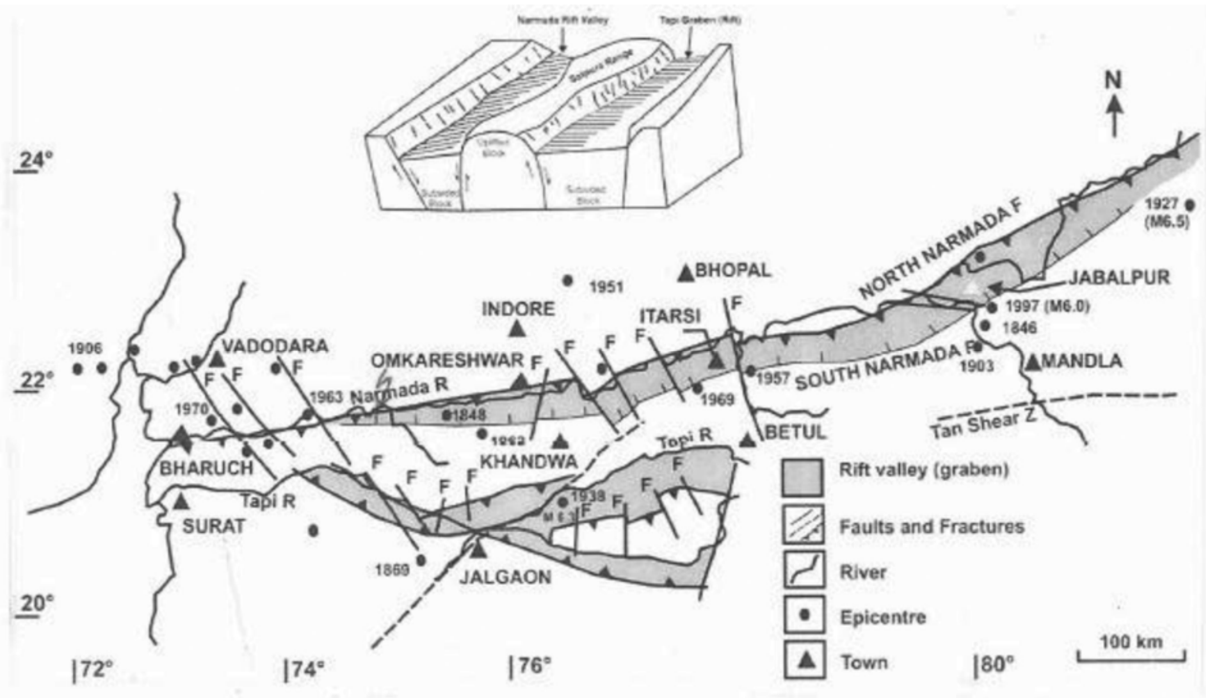

Figure 9. Narmada rift valley is defined by two major ENE–WSW trending deep faults. Notice the rift valley being cut and offset by more recent active faults transverse and oblique to the trend of the rift. Occurrence of earthquake indicates on-going movements on faults. Map after Krishnaswamy and Raghunandan[23], Epicentral distribution after Rajendran and Rajendran[24]. (Inset) Block diagram shows how a rift valley is formed. The Satpura is a horst mountain between the two rifts occupied by the Narmadā and Tāpi rivers.

India, witnessing violent as well as quiet tectonic movements.

South of Omkāreshwar in the Deccan Plateau is another shrine of great importance – *Trayambakeshwar Jyotirling*. In the lava terrain of the Deccan Volcanic Province, three spectacular spurs emerge from a high point represented by the Brahmagiri at the extreme northern edge of the Sahyādri Range. These three spurs make what strikingly resembles a trident – a *trishūl*, pointing northwards (Figure 8 *b*). The spurs formed when the northwards flowing lobes of the lavas froze about 65 m.y. ago[25]. In the amphitheatre-like depression between two spurs – between two *shūls* (blades of trident) – is the source of the River Godavari. Not far from the springs feeding the Narmadā is the seat of *Trayambakeshwar Jyotirling* (Figure 8 *b*). The three spurs, make what was presumably regarded as the Trishūl, the weapon that Shiva wielded.

Western India

In the western extremity of the Indian subcontinent, *Somnāth Jyotirling* is situated in Prabhāskhand or Prabhāskshetra of the Purāna times, but today known as Saurāshtra in Gujarāt. The present Somnāth temple is built on the coast not far from Chorwād–Verāwal towns on the Quaternary Miliolite Limestone. However, to my mind, it is the Girnār hills adjacent to Junāgarh that conforms to the design and specifications of the geological marvel and of the *Jyotirling*. The 341-m high solitary eminence in the midst of plateau of flat lava beds is made up of the upper part of the laccolith 15 km across. The laccolith evolved as hot magma congealed in the form of a bun-shaped body within the layers of Deccan lavas (Figures 10 and 11). The emplacement of the magma pushed up and sideways the lava beds above the bun-shaped magma body (Figure 10 inset), giving rise to a circular rim of hills made up of upturned lava beds. The dark coloured central body (Figure 11 *b*) – the laccolith – is constituted of heavier olivine–gabbro in the lower part, diorite in the middle and lighter monzonite at the top, implying gravity-induced differentiation of the magma derived from the upper mantle beneath the crust[26,27]. This rim of hills was later penetrated by granophyre and nepheline-syenite forming a ring dyke forming a white garland around the dark coloured Girnār.

While the central plug-like top of the Girnār laccolith resembles a Lingam, the circular depression with a rim of hills around it made up of upturned lava beds looks similar to a Yoni, the totality giving the impression of Lingam–Yoni pair (Figure 11).

The *Bheemeshwar* or *Bheemashankar Jyotirling*, at the source of the River Bheemarathi (Bhīmā) is situated in the proximity of a precipitous high scarp (Figure 12 *a*) formed as a result of faulting down a few hundred metres of the *larger part of the catchment* of the Bhīmā River that still has amazingly abundant discharge despite substantial loss of its recharge area. The fault, along with a number of associated NNW–SSE trending faults, seems to have destabilized the Sahyādri Range in this region as borne out by, among others, the July 2014 catastrophic landslide in the Ambegāon tālukā (Pune district) that wiped out Malin village with more than 150 people.

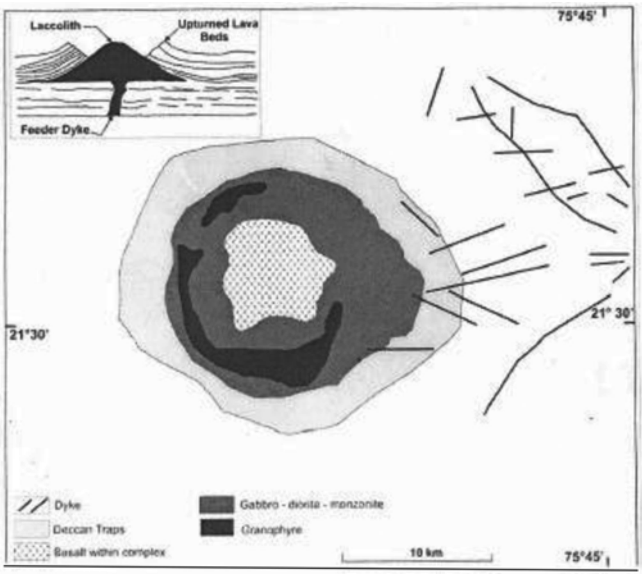

Figure 10. Sketch map of the Girnār complex in the Deccan Volcanic Province in Saurāshtra (based on Auden)[32]. (Inset) Diagrammatic profile of a laccolith that the Grinār magmatic body is. Notice turning up of the overlying lava beds following intrusion or pushing up of hot magma.

Southern India

In southeast Āndhra Pradesh, the generally eastward-flowing Krishnā River abruptly turns northwards, then eastwards and then immediately southwards and finally east–north–eastwards again making four pronounced rectangular bends. The peculiar sharp bends of the river form a striking box-shaped drainage (Figure 12 *b*). This drainage pattern gives the impression that the Krishnā River was pushed or driven northwards from its earlier direction. The abrupt swerving of the gently flowing river is attributed to neotectonic movements on the set of two parallel strike–slip faults trending north–south in the Precambrian Cuddapah terrane. Interestingly, east of the Srisalam area, in the Eastern Ghat Mobile Belt which is characterized by NNE–SSW and NW–SE lineaments, the Krishnā River flowed in the past through many palaeochannels – abandoning one water course for another, and

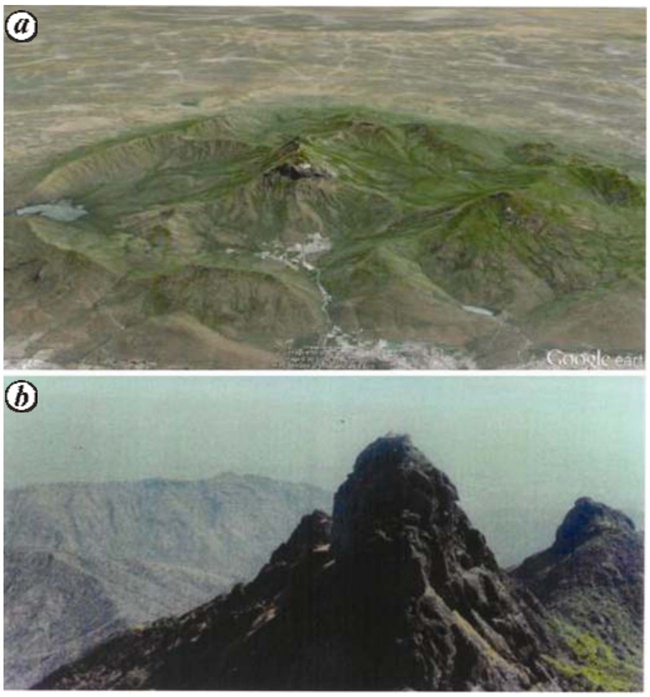

Figure 11. ***a***, Satellite imagery of the Girnār Hills showing the top of the intrusive laccolithic body resembling a *lingam*, surrounded by a circular depression with peripheral ring of hills looking like a *Yoni*. It is the outwardly dipping lava beds that form a ring of hills along the periphery. (from Google Earth); ***b***, View of the top of the laccolith in the central part resembling a *lingam*. (Courtesy: Hetu C. Sheth, Mumbai).

was deflected from the general easterly to southeasterly course, the deflection caused by what has been described as 'palaeo-relief' or ancient high ground[28]. The existence of the ancient high ground has been proved by gravity, magnetic and three-dimensional (3D) seismic data. It is quite evident that the Srisailam feature is just not a geomorphic anomaly but an eloquent testimony to development of considerable neotectonic importance that took place in the Krishnā Basin. The incised course of the Krishnā testifies to the uplift of the Srisailam block, atop which sits the *Mallikārjun Jyotirling*. The Srisailam hill seems to be a horst resulting from uplift and concomitant northward movement of the block between the two parallel faults.

This shrine embodies both Shiva and his consort Pārvati – Mallikā ≡ Pārvati + Arjun ≡ Shiva[4]. Eloquent is the message of this much venerated shrine – Shiva and Shakti (Pārvati) are inseparable and indivisible. The shrine thus brings the Shaiv and Shākt sects together on one platform.

Effective endeavours for unity

Keen observers and profound thinkers that the wandering-exploring sages and seers (*rishis* and *maharshis*) of the Purāna and the Mahābhārat times that they were, they realized and recognized the significance of geological marvels. The rulers and the commoners alike were made to go on pilgrimage to these geological wonders, characterized by spectacular landform, by investing on them the aura of divinity. In addition to the 12 holy shrines of Shiva, there were then more than 500 places of pilgrimage[29] located in different terrains across the vast expanse of the country.

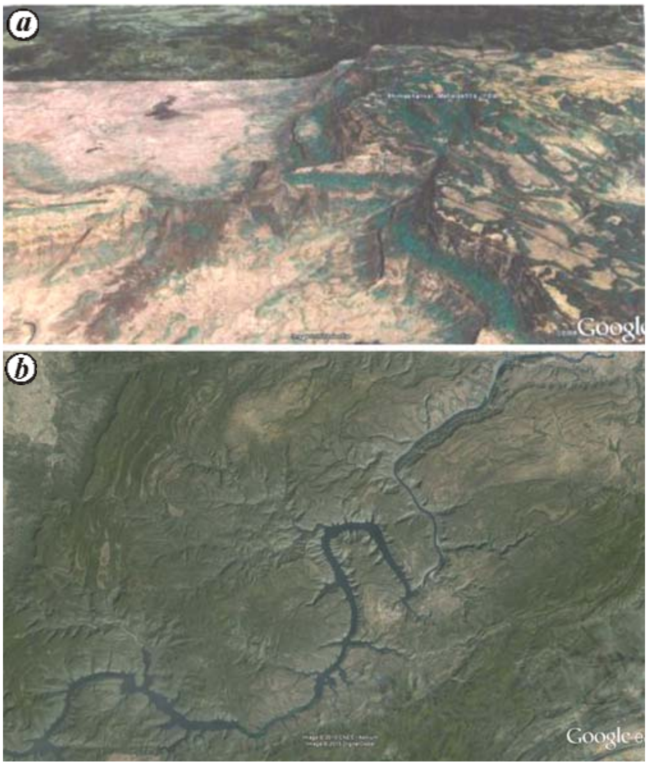

Figure 12. ***a***, Bheemeshwar or Bheemashankar Jyotirling is at the source of the Bhīma River. The larger part of the Bhīma's recharge area has been faulted down along a series of vertical faults now marked by scarps. ***b***, On the Srisailam Hill is located *Mallikarjun Jyotirling*. The shrine is situated atop a fault block delimited by two N–S faults. The hill represents a horst (Google Earth).

The idea behind the practice of visiting shrines and centres of pilgrimage (*teerthsthāns*) was to persuade and spur the pilgrims and travellers to know people who lived in different terrains, spoke different languages, ate and dressed differently, had different lifestyles and observed different socio-cultural practices. In the period the *Purānas* and epics describe, there was no religion as we understand today. The people followed their duty (*dharma*) as ordained by their society. Also, pilgrimage or travelling to different terrains inhabited by different groups of people was considered an imperative *dharma* (duty) – a must at least once in the life of an individual.

The pilgrims criss-crossed the country that spread far and wide. They not only tasted and enjoyed adventures, but also mingled and interacted with people along the routes and around the centres of pilgrimage. The pilgrimage provided a fertile ground for cross-fertilization of thoughts and cultural elements[30]. There was bonding at religious and cultural levels[1]. Presumably, it may have been a movement to *promote the idea of One Nation – One India*.

This was effective albeit subtle way of national integration – unifying the people of different regions. The very locations of the *Jyotirlings* and establishment of shrines in all parts of the country unequivocally demonstrates remarkable and very effective efforts made in the Purāna times for forging unity among the people of the Indian subcontinent.

One may not believe in the divinity of Shiva or even in the historicity of the narratives in the *Purānas* and the epics, but one cannot deny that the locations of most of Shiva's venerated symbol are places of stunning geomorphic splendour and extraordinary geological features crafted by uncommon earth processes. Such picturesque places attract believers and non-believers alike. They have been attracting people from far and near for thousands of years. Either driven by devotion and religious fervour, or by pure curiosity, the people of the largest and predominant segment of the Indian population living in all parts of the country have been embarking on unending pilgrimages since time immemorial to the seats of revered symbol of divinity, resulting in closer interaction and development of bond of understanding and unity.

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