A dense network of GPS stations to measure the rate of change and building up of strain along the plate boundaries has been set up and is being augmented in the Andaman and Nicobar islands and the Himalaya. This needs to be supported by a satellite-borne interferometric synthetic aperture radar to measure the strain. Such data from Sentinel-1 satellite are expected to be available in the near future and will provide long-term strain measurements. NISAR, a joint venture between NASA and ISRO, to be launched in the near future, will also provide interferometry capability and facilitate measurement of strain everywhere.

The study of the earth's magnetic field provides information about the interior of the earth. The MAGSAT in eighties and CHAMP during the last decade have provided new knowledge about the interior of the earth. Recently, SWARM, a trio of three satellites, has been providing immense data on the magnetic field to unravel the mysteries of the solid earth[15]. The measurements carried out during the first six months confirmed that the magnetic field is weakening with dramatic decline in the western hemisphere and strengthening in the southern Indian Ocean[16]. The magnetic contributions from the mantle, crust and oceans need to be studied to probe the interior of the Indian subcontinent using SWARM satellite data.

Satellite altimetry has emerged as a powerful tool for gravity survey and geoid studies over offshore regions[17]. As such missions are continuing, a very high resolution database needs to be developed for such studies. Data from GOCE (Gravity field and steady state Ocean Circulation Explorer) have been used to produce global anomaly maps of gravitational gradients and infer structure of the interior of the earth[18]. Use of available data from SWARM, along with GOCE and GRACE (Gravity Recovery And Climate Experiment), and altimeters should be initiated for probing the interior of the earth. This needs to be supported by about 5–6 deep boreholes, may be about 3–4 km deep in the Indo-Gangetic plains, north and south of the Narmada–Son lineament, and north and south of Palghat gap to measure the build-up of stress as well as to understand the dynamics of faulting, fault nucleation and propagation processes in rocks. Deep drilling in the Andaman subduction zone is another critical requirement.

A National Geochronological Facility to support dating of various events is being set up in the Inter-University Accelerator Centre at Delhi; it is vital in all the programmes of geoscience. It will house HR-SIMS and ion accelerator along with other support facilities. Earth is dynamic in nature, and observing and attributing changes that occurred in the past, as well as their global and regional patterns are critical to define our response to the current environmental change.

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Unique geological and geomorphic features of River Ken with a bedrock channel

River Ken (also known as Karnavati) – a major north-flowing tributary of River Yamuna – has attracted much attention during the past two decades for the controversial Ken–Betwa Link project, touted to be the first of India's ambitious river interlinking programme. River Ken hosts along its course the Panna National Park and Tiger Reserve, a Gharial Sanctuary and several historical sites, all of which lie within 15 km from Khajuraho, a World Heritage Site in Madhya Pradesh (MP), India. River Ken is probably the only Indian river with near-pristine water quality and which has so far escaped from the impacts of a large dam on its main stem, except for two weirs at Bariyarpur (constructed in 1903) and Gangau (in 1915) in its middle reach. The 427 km long River Ken with a total basin area of more than 28,000 sq. km qualifies to be a medium river system. However, only a few preliminary studies on water quality, biodiversity and hydrology have been made[1–4]. The River Ken is also distinguished by its geological and geomorphic features, as it forms a single-thread, bedrock channel that passes through deeply incised valleys with steep banks and gorges as well as a series of falls, but its fluvial geomorphology has never been studied[5,6].

Here I report the occurrence of interesting geological and geomorphic features, most likely unique in India, and discovered in the middle reach of the River Ken during field surveys since 2014. The current severe drought helped the survey by rendering the river channel more accessible. The River Ken, rising northwest of Katni, meets its larger tributary – the Sonar, near village Kamtana, Panna district, MP, where the two rivers fall into a 12–15 m deep and about 2 km long gorge forming a deep lake. Downstream of the lake, for about 1 km the river has a wide bedrock channel which is crossed by the Amanganj–Kishengarh road bridge. About 200 m downstream from the road bridge, the river is joined on its right bank by River Mirhasan. Here, the River Ken has a 350–400 m wide, relatively shallow channel with typical low gradient, scabland morphology which is seen also along most of its course, but fine sediment deposits are common along the banks.

Here the river itself suddenly plunges into a narrow (less than 3 m), 12–15 m deep rift as a rocky inner channel that widens gradually further downstream, but cannot be seen readily from the surface. This place is known as Pandavan, because according to a legend, the Pandavas visited here during their exile. According to one version of the legend,

Figure 1. Views from River Ken at Pandavan, Panna district, Madhya Pradesh, India. ***a***, Fault line (marked by yellow line) along the left bank viewed from the right bank. ***b***, Ripples formed over the rocks on the channel bed. ***c***, Potholes at the point where River Ken falls into a gorge (view towards upstream). ***d***, Coalesced potholes in the river. ***e***, Potholes with large stones inside. ***f***, Evidence of plucking – rock with a pothole thrown over other rocks. ***g***, Fall at Gehrighat (view towards upstream).

the Pandavas wanted to stop the river, but it turned into a fish and slipped under their feet. According to another version, the river did not want to disturb the Pandavas and hence went belowground.

Geologically, a deep fault runs along the left bank and can be visually marked from a distance (Figure 1 *a*). The left side forms a nearly vertical scarp and has a 1–2 m higher elevation than the right side. Most interesting, however, are the numerous ripples, flutes and about a million potholes over a distance of more than 2 km. These potholes, on almost every boulder, vary greatly in shape and size, are both horizontal and vertical, and occur from the surface of the river bed down to the level of the water in the channel, and on the left bank scarp (Figure 1 *b–e*). In general, the potholes at this site are larger (up to 3 m in diameter) close to the knick point at the surface and near the water channel in the gorge. Majority of the potholes are visibly carved out by the grinding action of small and large-sized gravel in swirling water moving over the rocks. Many potholes contain pebbles and even large stones, and in numerous cases, these potholes have coalesced. Smaller potholes, ripples and flutes on the surface of the bedrock channel may have been formed by turbulent flows, whereas vortex formation during huge discharges seems to be largely responsible for the massive potholes closer to the main channel – the inner channel. Turbulent flows have also left a signature of plucking of large boulders (Figure 1 *f*).

Potholes have been described from rivers with bedrock channels, such as the Indrayani and Kukadi in Maharashtra, India[7–9], and Indus in Pakistan[10]. While the potholes at Pandavan are somewhat similar in appearance to those at Nighoj near Pune, Maharashtra[9], the former are far more extensive and in sandstone in contrast to those at Nighoj being in basalt. Although potholes are considered to be the most effective way of erosion and incision in bedrock channels[11], tectonic processes have apparently played a major role because several other gorges occur further downstream up to the Ken Gharial Sanctuary. Another interesting site is only about 6 km downstream at Gehrighat within the Panna Tiger Reserve, where the river has formed a wide fall and a deep, long gorge (Figure 1 *g*). Gehrighat is an important habitat of vultures in the National Park. Here tectonic faulting appears to have contributed actively to knickpoint initiation and possibly recession. Mention should be made here of another tectonic fault that caused the formation of another knick point – the Raneh Falls – about 50 km downstream of Gehrighat, along with a narrow, 5 km long and 30 m deep gorge which has also multi-coloured crystalline granite rocks. Interestingly, pothole formation is weak and negligible at this site.

Among the many rivers flowing through narrow gorges and across north-facing escarpments in the Rewa and Bundelkhand Plateaus, the River Ken offers a unique example of forming fluvially sculpted channel morphology in two different rock types (Vindhyan sandstone and Bundelkhand granite) and two different geomorphic settings within about 60 km distance. The hitherto unknown site at Pandavan deserves detailed studies regarding its geological origin, past hydrology and the development of potholes which are unique in the country. The site is certainly of historical and cultural interest besides its value for tourism and education. It deserves to be declared as a geoheritage site before it is lost to submergence under the Daudhan reservoir (FRL 288 m) proposed to be constructed for the Ken–Betwa Link project.

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