sediments have basic Lower Gondwana composition. The present study further supports the contention that during Early Permian, the Karakoram was located along the northern margin of Gondwana, i.e. the Karakoram plate was Peri-Gondwanan, as envisaged by Upadhyay *et al*.[6].

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Evidence of formation of potholes in bedrock on human timescale: Indrayani river, Pune district, Maharashtra

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In resistant substrate, potholes require hundreds to thousands of years to form. Here we report evidence for the formation of several potholes (0.2–1.0 m in diameter) in about 60 years, within man-made channels and pits carved in bedrock basalt in the channel of the Indrayani river. Although documentary evidence is lacking, available information indicates that the man-made channels and pits were most likely carved in mid-1940s. The evidence demonstrates that even in resistant bedrock, such as basalt, measurable bedrock erosion can take place in a few decades. This finding has enormous implications for improving the understanding of the rates of formation of rocky channels and gorges in large Indian rivers, where the energy levels are higher by several orders of magnitude.

POTHOLES are one of the most common and spectacular features formed in bedrock by rapidly flowing rivers. It is generally assumed that due to considerable resistance to

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erosion by the bedrock, potholes take hundreds to thousands of years to form[1]. Direct measurement of bedrock erosion is precluded by slow rates of erosion on human timescale[1]. Here we report the occurrence of typical potholes within the Indrayani river channel, which were most likely formed in less than a century.

The site under consideration is located at Shelarwadi village (18°42′8″N and 73°42′42″E) about 30 km from Pune. Close to this settlement, the Indrayani river, a tributary of the Bhima river, has developed scabland topography[1] in bedrock basalt. The bed of the river is intensely potholed, and the swift flowing river has carved multiple and deep inner channels (3–7 m deep) in basalt rock (Figure 1)[2]. Wide rocky benches are present on both sides of the multiple flow-path channel of the Indrayani river (Figure 1)[2]. The inner channels have strongly undulating walls[2], indicating that the river is actively incising in the rock[1]. Several hundred potholes of different dimensions occur along the entire reach, which covers an area of ca. 350 m × 210 m. The occurrence of potholes, grooves and inner channels[2] suggests the dominance of corrasional erosion[1]. The channel and the potholes are mostly developed in compound lava flows with amygdaloidal characters.

During the course of geomorphic investigations, a few man-made features were observed in the scabland area. Three channels of uniform width were observed on the left bank of the river and over the wide rocky bench (Figure 1). The uniform width (61 cm or 2′) and chisel marks on both the sides of the channels indicate that man has carved these channels. The depth of the deepest channel (CH1) is about 1.7 m at the lower end, and the length of the channel is more than 10 m. The upper end is covered and buried under the ramp of a walking bridge. In addition to this, several square pits (46 cm × 46 cm and 61 cm × 61 cm or 1.5′ × 1.5′ and 2′ × 2′), sometimes occurring in a straight line, were also observed over the rocky bench. The geometric form of these pits suggests that these are man-made features.

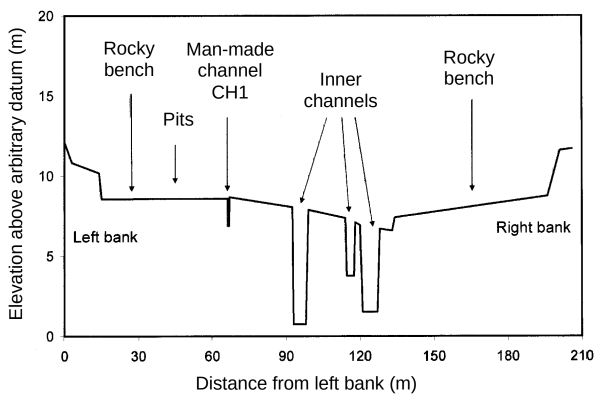

Figure 1. Profile across the Indrayani scabland topography showing rocky benches, inner channels and the location of the deepest man-made channel (CH1) and pits. The profile is based on Pentax EDM survey.

Evidence of active fluvial corrasion and abrasion in recent times is provided by the smooth and polished bedforms of these man-made channels and by the near-absence of chisel marks close to the bottom. Most of the square pits have been partially or completely rounded and the base of some of the pits has been enlarged by gyratory erosion. The most fascinating aspect, however, is the occurrence of potholes of various dimensions within these man-made channels and pits (Figures 2 and 3). Measurements indicate that most of the potholes range in diameter between 0.2 and 1.0 m. The largest recently formed pothole (length = 110 cm; width = 80 cm and depth = 129 cm) is located in the deepest man-made channel (CH1; Figure 2 *b*). The occurrence of these potholes within the man-made channels and the pits indicates that the potholes are certainly younger than the artificial features and

a

b

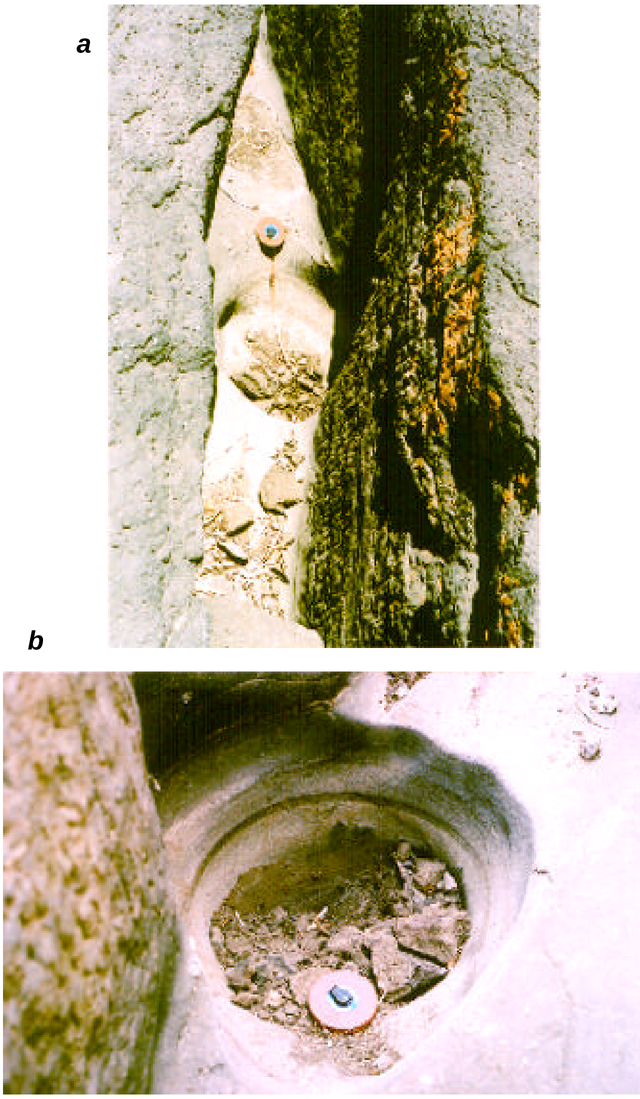

Figure 2. ***a***, Deepest man-made channel (CH1) from the top. Chisel marks are clearly seen on the right side wall of the man-made channel, and the largest pothole is present roughly in the centre, close to the measuring tape. ***b***, A close-up of the largest pothole (110 cm × 80 cm × 129 cm) in CH1. Diameter of the measuring tape is 15 cm.

were formed very recently. Even if we consider the facts that the narrow width and greater depth of the CH1 might have artificially maximized shear stress and unit stream power for a given discharge, and that the chiseling would have weakened the rock, the rate of pothole formation appears to be unusually high. The high rates of pothole formation are also surprising because the largest pothole (Figure 2 *a*) contained within the CH1 is several metres away and above the main channel of the Indrayani river (Figure 1), and thus is outside the zone of highest stage-discharge and active fluvial corrasion. The recently formed potholes, therefore, provide evidence of unusually rapid development and growth of potholes in resistant substrate, unknown so far from any other river in India and elsewhere. The evidence also implies that the rate of bedrock erosion and pothole formation must be even higher in the naturally formed inner channels (Figure 1), because of frequent maximization of stream power and shear stress.

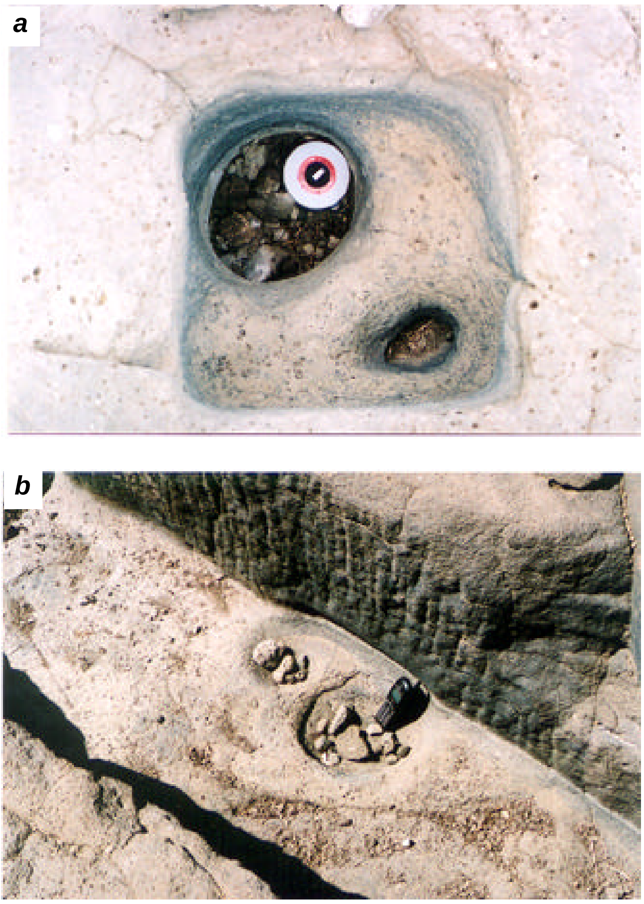

Figure 3. ***a***, A man-made square pit (1.5 ft × 1.5 ft) with two well-developed potholes. The dimensions of the bigger and rounded pothole seen close to the upper left corner are: length = 35 cm, width = 32 cm and depth ≥ 25 cm. The measuring tape is 13 cm in diameter. ***b***, Another man-made channel with incipient potholes. The width of the channel is 61 cm (2 feet). The length of the bigger pothole on the right is 28 cm, and the width and depth are 18 cm and 2.5 cm respectively. Chisel marks are clearly visible on the right side wall. Note the abraded and polished nature of the channel bottom. Length of mobile is 13 cm.

Unfortunately, no documentary evidence of the year in which these man-made channels or pits were carved is available to determine the rates of pothole formation. Field observations show that the channel walls with chisel marks often have a dark coating and moss is present in patches on the walls. This indicates that the channels are at least several years or a few decades old. Further, inquiries with the residents living on the banks of the river for several decades reveal that the man-made channels and pits were already in existence before most of the middle-aged people were born. This implies that the channels and pits are at least 40–50 years old. A few older folks remember these features to be contemporary to a small masonry weir built across the river channel (slightly upstream of the concrete bund) during the Second World War. The channels were most likely carved to divert the river water to a depression over the rocky bench. However, the purpose of the square pits could not be ascertained. Available information further indicates that the British built the masonry weir sometime during the mid-1940s (Second World War) after a Military Depot was established at the site. It is therefore likely that the potholes were formed during the last six decades or so.

It could be argued that there is a strong possibility that the man-made channels and pits are older than 1940 and could be of late Historical or late Medieval period. There is no evidence either in its favour or against it. However, the width of the channels, which interestingly is 2 ft, strongly suggests that the channels were not carved during the pre-British era. This is because there is no reason why anyone should have adopted the Imperial units of measurement (ft) before the advent of the British. Similarly, the dimensions of the square pits are also in Imperial units (1.5 ft × 1.5 ft or 2 ft × 2 ft). Since Pune came under British rule in 1817 (ref. 3), it can be confidently concluded that the man-made channels and pits were carved sometimes during the last 190 years. Even if we accept that the potholes were formed during the last two centuries, the rates are extraordinarily high. However, this appears doubtful because apparently there is no reason why the British would dig channels and pits in the river channel, without an establishment nearby. The only British establishment close to this site came up in the mid-1940s, i.e. during the Second World War. Hence, taking into account the information provided by locals it seems more logical to deduce that the channels (and pits) were carved after British occupation of the study area and the establishment of the Depot in mid-1940s to divert the river water after the construction of the masonry bund.

If correct, this would suggest that the potholes, measuring in diameter from 20 cm to 1.0 m, were formed and enlarged in just the last six decades or so. This observation is worthy of note, because such high rates of pothole formation and growth in resistant substrate are not known from any part of India, and there are only a few known examples from other parts of the world. One example is known from Alaska, where potholes up to 6 m in diameter and 5 m in depth were formed in sandstone in 85 years[4]. Bloom[5] has reported about four times increase in the pothole dimensions developed into shale and siltstones between 1963 and 1983, in the Coy Glen, New York. It is most important to note that these rapidly formed potholes were developed in relatively less resistant substrate. In the Indian subcontinent, although a few attempts have been made to estimate or measure the rates of bedrock erosion on the Indus river on the basis of cosmogenic dating and by using drill holes in rocks[6–8], there are no reports on quantitative estimates for rates of pothole erosion. Therefore, the results of this study are significant because the evidence shows that discernable bedrock erosion can take place on human timescale.

The findings of the present study have implications for improving our understanding of the less-studied bedrock river channels in India, which are dominated by amazingly high levels of power expenditure during monsoon floods[9,10], but are generally assumed to be more stable and less dynamic than the alluvial river channels[9].

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Impact of insecticides on sucking pests and natural enemy complex of transgenic cotton

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Development of transgenic cotton appears to be effective in managing the bollworm population. However, selection of suitable techniques to manage the sucking pest population on transgenic cotton is needed. Studies were made to assess the impact of insecticides on sucking pests and natural enemy complex on transgenic cotton. Results of field studies conducted during kharif 2002 at the Department of Cotton, Tamil Nadu Agricultural University, Coimbatore under irrigated conditions revealed that seed treatment of transgenic cotton with imidacloprid @ 5 g kg^{-1} of seeds was more effective than other treatments in keeping the populations of leafhoppers, *Amrasca devastans* (Dist.); aphids, *Aphis gossypii* (Glover); thrips, *Scirtothrips dorsalis* (Hood) and whitefly, *Bemisia tabaci* (Gennadius) below economic threshold level up to 40 days after sowing. The studies also showed that seed treatment of transgenic cotton with imidacloprid was not only safe but also attracted predators, viz. coccinellid beetles, *Coccinella septumpunctata* (Linnaeus) and *Cheilomenes sexmaculatus* (Fabricius); green lace wing, *Chrysoperla carnea* (Stephens) and Lynx spider, *Oxyopes javanus* (Thorell); orb spider, *Argiope minuta* (Karsh); wolf spider, *Lycosa pseudoannulata* (Boesenberg and Strand); long-javed spider, *Tetragnatha javana* (Thorell); *Neoscona theisi* (Walcknear) and *Peucetia viridana* (Stoliczka) in transgenic cotton.

COTTON, *Gossypium hirsutum* L., an important industrial crop of the world, is grown in an area of more than 38 million hectares (m ha), of which approximately 24% is in India. Punjab, Haryana, Rajasthan, Maharashtra, Gujarat, Madhya Pradesh, Andhra Pradesh, Karnataka and Tamil Nadu are the major cotton-growing states of India. India is the third largest global cotton producer. Despite the large area (9.2 m ha), productivity is far below (290 kg/ha) the global average and production is only 19.6 million bales[1,2]. The low yields (up to 35–40%) are mainly attributable to insect pests.

About 162 species of insects occur in cotton at various stages of growth, of which 15 are key pests. Sap feeders, viz. leafhopper, *Amrasca devastans* (Dist.); aphid, *Aphis gossypii* (Glover); thrips, *Scirtothrips dorsalis* (Hood) and whitefly, *Bemisia tabaci* (Gennadius) damage the cotton crop with regular occurrence at different growth stages,

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