(mainly fayalitic) would not be deleterious to atmospheric corrosion resistance because the protective passive film covers the surface before the initiation of localized attack[3], due to the mild corrosivity of atmospheric environment. On the other hand, entrapped slag inclusions can be a blessing in disguise because adherence of the surface protective layers are superior on wrought irons[3]. Moreover, the entrapped slags would assist in down-line manufacturing processes by providing a self-contained flux for the operations.

The maintenance that would be required to preserve phosphoric irons against atmospheric corrosion is quite simple. If conventional surface coating processes like painting are employed, phosphoric irons would fare better than mild steel. The surface of phosphoric irons can be maintained in a pristine condition even without painting by suitably allowing the protective passive film to protect the surface. This can be easily achieved by periodic buffing operations on the iron surface. The superior qualities of the protective films that form on smoothly buffed surfaces are well recognized for stainless steels. The surface finish that develops on well-buffed phosphoric iron surfaces is truly amazing. By proper buffing operations, a golden hued surface with a shiny appearance can be developed because of the nature of the passive film that forms on phosphoric irons.

A great benefit will also accrue in the mining area with the possible large scale use of phosphoric irons for atmospheric exposure applications. At present, the high-phosphorus containing iron ores are not being deliberately mined. With the realization that superior corrosion resistant phosphoric iron can be produced from these ores, the great reserves of high-phosphorus iron ores can be exploited usefully. This would be very relevant in the Indian context because we possess large reserves of high phosphorus iron ores.

The oft-cited problem that phosphorus causes cold shortness (i.e. embrittlement during cold working) may not actually be the case if careful studies are conducted on the mechanical behaviour of phosphoric irons. Such studies have not been conducted on a large scale utilizing the sophisticated tools of modern scientific investigation because research in the early 1900s indicated the deleterious effect of P on mechanical behaviour. However, recent studies on the mechanical properties of phosphoric irons have revealed that the deleterious effect of significant phosphorus content in iron may actually be offset by the presence of a small amount of carbon[4]. Phosphoric irons possess adequate strength and ductility for manufacturing objects for normal atmospheric exposure applications (i.e. frames, non-critical structural members, etc.). It is interesting to note that ancient ironsmiths deliberately chose phosphoric irons over normal iron for their working operations as revealed by the high P contents in archaeological irons from different parts of the world[4].

An ardent plea is advanced, through this letter, to study the feasibility of drastically modifying existing iron and steel-making practices in order to produce and apply phosphoric irons on a large scale.

1. Balasubramaniam, R., *Delhi Iron Pillar: New Insights*, Indian Institute of Advanced Study, Shimla, New Delhi, 2002.
2. Balasubramaniam, R., *Corrosion Sci.*, 2000, **20**, 2103–2129.
3. Chilton, J. P. and Evans, U. R., *J. Iron Steel Inst.*, October 1965, 113–122.
4. Stewart, J. W., Charles, J. A. and Wallach, E. R., *Mat. Sci. Tech.*, 2000, **16**, 275–282.

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Recent findings on the Acheulian of Isampur excavations and its dating

Paddayya *et al.*[1] claim discovery of 'the oldest known (stone age) site in India' at Isampur, which is dated over a million year. Earlier, Mishra *et al.*[2] had claimed the site at Bori, near Pune, to be the earliest and 0.67 Ma old. Dating of these Acheulian sites[1,2] is suspect.

The Acheulian site at Isampur (16°30′N: 76°29′E) is set in a 20–30 cm thick calcareous silt above the Bhima Group limestone. Fragmentary vertebrate remains associated with the Acheulian tools have not been identified to specific levels and contain no Middle Pleistocene forms. Based on fresh condition of the artefacts, their occurrence at the raw material source, and the recovery of a large number of small-sized debitage fragments, the assemblage is assumed to have virtually escaped erosion and reworking before being buried under colluvially deposited silt[1]. Under such a setting, cultural elements and vertebrate remains lying on the limestone floor may belong to more than one age and get mixed up. This is corroborated by wide range of $^{230}Th/^{234}U$ radiometric dates on dental material from the Acheulian sites in the Hunsgi and Baichbal valleys, which ranges in age from 174 to > 350 ka. Such dating was not attempted on Isampur site, but electron spin resonance (ESR) dating was done on two fossil teeth. The early U uptake (EU) ages set the minimum age for the site at 730 ± 100 ka, while the recent uptake (RU) ages set its maximum possible age at 3.12 ± 0.40 Ma with a mean age of 1.27 ± 0.17 Ma assuming linear U (LU) uptake[3]. 'Considering the technological and typological features' the Isampur assemblage was assigned much older age (0.5–0.6 Ma) than the nearby sites. Its age was increased two fold further and the older average ESR age 1.27 Ma was chosen[3] without any additional reason. The inference that the Isampur site is the oldest Lower Palaeolithic site in the subcontinent is thus not convincing. The absence of any Mid-Lower Pleistocene faunal elements is also noteworthy.

Earlier, the Acheulian site at Bori was claimed to be the oldest from the Peninsular India[1,2,4,5], which was also strongly contended[6,7]. Highly discrepant radiometric ages (K–Ar[4,8], Ar–Ar[2], fission-track[8], TL[8]) were obtained from a differ-

ent component of the ash material, which is closely associated with the artefacts. Thus the age of Bori Acheulian site is unclear from these radiometric dating records.

The Palaeolithic stone implements in the Indian subcontinent generally occur in two biostratigraphically recognizable gravel horizons. The older gravel bed, characterized by Middle Pleistocene fauna, till now provides the oldest stratigraphic record of Lower Palaeolithic tools represented by hand axes, cleavers, choppers, etc. This gravel bed has also yielded the only fossilized calvarium of early man from India[9]. The gravel bed is assigned late Mid Pleistocene age (200–300 ka)[7] based on the evolutionary grade of *Cuon alpinus tripathii* and the archaic *Homo sapiens*-like characters of the Narmada calvarium.

The younger gravel bed and overlying sand is assigned Upper Pleistocene age on the strength of younger extant mammalian assemblage, the presence of the 75 ka Toba Ash Bed marker and association of Middle Palaeolithic tools. But correlation of the older and younger gravel beds often becomes problematic as the diagnostic mammalian faunal elements are rarely preserved.

A significant improvement in the status on correlation of Quaternary sediments and Palaeolithic sites had resulted after the recognition of the 75 ka Youngest Toba Ash Bed (YTA) from the Narmada and Son basins[10] and subsequently from several other alluvial and ocean basins from the Indian region[6,11]. Although partly reworked, they still represent isochronous event marker[6,7]. However, the ash bed at Bori was regarded by some to be much older and different ages were assigned to it[2,4,8]. Additional studies on geochemical characterization of Toba Ash Beds, and fission-track dating of its two samples from Pawlaghat in Narmada and Gandhigram in Purna basins, reaffirm that all Toba Ash occurrences in India belong to 75 ka youngest event[12]. The Acheulian tools from Bori area occurring in close association with the Toba Ash Bed are thus reworked material in younger sediments[7,12].

Evidence of reworking of stone implements has often remained unrecognized. Therefore, the 'discovery' of oldest Acheulian culture in the Indian subcontinent, whether at Isampur or at Bori based on their primitive character alone as yet remains illusive and undated.

1. Paddayya, K. *et al.*, *Curr. Sci.*, 2002, **83**, 641–647.
2. Mishra, S., Venkateshan, T. R., Rajaguru, S. N. and Somayajulu, B. L. K., *Curr. Anthropol.*, 1995, **36**, 847–851.
3. Blackwell, B. A. B., Fevrier, S., Blickstein, J. I. B., Paddayya, K., Petraglia, M. D., Jhaldiyal, R. and Skinner, A. R., *J. Hum. Evol.*, 2001, **40**, A3.
4. Korisetter, R. *et al.*, *Man Environ.*, 1989, **XIX**, 29–41.
5. Mishra, S. and Rajaguru, S. N., *Quat. Res.*, 1994, **41**, 396–397.
6. Acharyya, S. K. and Basu, P. K., *ibid*, 1993, **40**, 10–19.
7. Acharyya, S. K. and Basu, P. K., *ibid*, 1994, **41**, 400–402.
8. Horn, P., Müller-Schnius, D., Storzer, D. and Zöller, L., *Z. Deutsch. Geol. Gesell.* 1993, **144**, 326–329.
9. Sonakia, A., *Rec. Geol. Surv. India*, 1984, **113**, 159–172.
10. Basu, P. K., Biswas, S. and Acharyya, S. K., *Ind. Miner.*, 1987, **41**, 66–72.
11. Pattan, J. N., Shane, P., Banakar, V. K., *Mar. Geol.*, 1999, **155**, 243–248.
12. Westgate, J. A. *et al.*, *Quat. Res.*, 1998, **50**, 107–112.

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Response:

It is conceded that Isampur excavation has produced only limited amounts of faunal material which cannot be identified to the species level. So Acharyya is fully justified in saying that the Isampur Acheulian site has no characteristic Lower/Middle Pleistocene fauna.

But the smallness of faunal collection from the site and its fragmentary nature does not mean that it has no dating value. Acharyya's doubts about the contemporaneity between the cultural material and faunal remains associated with it are devoid of justification. Both these materials occur together in a thin sedimentary unit (20 to 30 cm) consisting of stone blocks and artifacts, all set in a carbonate-rich silt matrix. The thinness of the horizon suggests that the time involved in its formation is not a prolonged one but rather a short one – probably some years or some tens of years. Close to this site we have other and equally rich Acheulian sites covered by silt deposits. Thus the inference comes up that once the cultural level at Isampur was covered up by silt deposits washed down from the surrounding uplands, the hominids shifted to other limestone outcrops in the vicinity. So there is no reason to postulate any time gap or dissociation between the cultural materials and faunal remains. It is here that the use of faunal material for dating the site assumes importance.

In terms of lithic technology and tool typology, the Isampur Acheulian assemblage certainly presents features which are quite archaic as compared to known Acheulian assemblages in the country. Thus the ESR dating of the site to 1.2 million years is not surprising at all. Some additional dates for the site by ESR method are being processed. As has been rightly recognized by Acharyya, this date of 1.2 million years is the average between the lower and upper limits. Our purpose has been to suggest that even South Asia could have very early sites of the Acheulian. Obviously more work and more dates are required to place this on a firm basis. The other and probably the more important contribution made by Isampur excavation lies in the new insights it has given about early homind behaviour, but unfortunately this aspect has been overlooked by Acharyya.

Acharyya mentions at length that alluvial deposits of the Narmada and Son rivers have cultural material and Middle Pleistocene fauna. Unfortunately, to the best of my knowledge all these materials are obtained from secondary contexts. These contexts probably involved long distance transportation, and provide no guarantee of contemporaneity of cultural and faunal materials. Use of alluvial contexts for cultural and chronological purposes in Indian prehistory is already *passe*. On the contrary, the real emphasis now is on identifying and studying primary or original context sites.

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