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### DISCOVERY OF A TEPHRA BED IN THE QUATERNARY ALLUVIAL SEDIMENTS OF PUNE DISTRICT (MAHARASHTRA), PENINSULAR INDIA

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A vitric rhyolite tephra bed has been discovered in the Quaternary alluvial deposits exposed in the Kukdi river section near Bori village, district Pune,

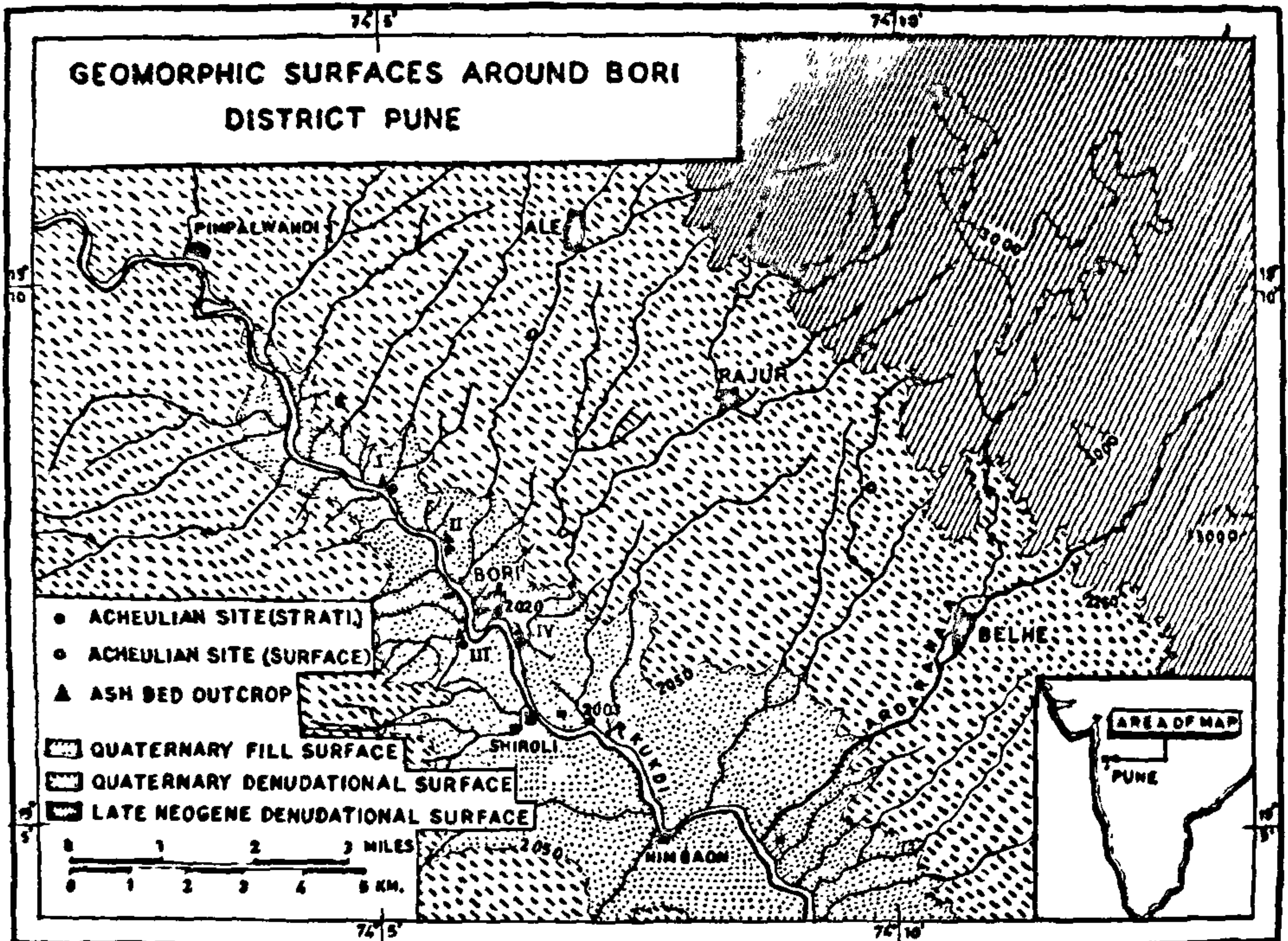


Figure 1. Location map of the study area. Sample locations are indicated as I, II, III and IV.

Maharashtra (figure 1). This discovery of a tephra interbedded in the Quaternary sequences of Peninsular India is significant as all the known Quaternary volcanic sources are quite distant in space and time. The preliminary K-Ar date of 1.4 Myr is the first indication of any Early Pleistocene record in this region.

The tephra is exposed at four locations along the Kukdi river between 74°04'E and 74°07'E (figure 1). It is underlain by 2-8 m of clays with occasional lenses of basaltic rubble and calcrete gravels. At location I, a channel lag gravel underlies the clay sequence. At location IV, a 3-m-thick gravel bar, containing an Early Acheulian tool, cuts into the ash lens. The gravel bar and tephra are overlain by yellow-brown calcareous silts with lenses of gravel and brown clays of Late Pleistocene age (figure 2).

The tephra has a sharp lower contact and follows the pre-existing depositional topography. The upper surface is exposed as an erosional bench 1-4 m above the present channel of the Kukdi river. At locations I and III, where the tephra is relatively thicker, a gradation in colour and compactness is

observed from the base upwards. According to the Munsell soil colour chart, the compact basal layers are white (10 YR 7/1) whereas the loose upper layers are light brown (10 YR 6/3).

Between locations I and IV (figure 1) the thickness of the tephra varies from 0.2 m to 1 m. At location IV, it caps compact brown clay.

The tephra consists of angular glass shards with minor amounts of pumice fragments. The average grain size of the tephra is coarse silt (5 φ). It is well sorted and is probably an airfall deposit. The absence of authigenic smectite characterizes its unaltered state of preservation. Analysis for bulk chemical composition and U-Th isotope measurements have been performed on the tephra. Table 1 shows the bulk chemical composition obtained by atomic absorption spectrophotometry. The high silica content typifies the rhyolitic character dominantly comprising isotropic glass shards (90-95%) and a few pumice fragments. The accessory minerals include feldspar, quartz and biotite. Due to very low occurrence of zircons and heavy minerals, only the whole-ash age of the samples could be determined by the K-Ar method<sup>1</sup>. The two samples BC and BD gave ages of 1.50 and 1.26 Myr respectively, yielding a mean age of 1.38 Myr (table 2). It is seen that K varies between 2.84 and 4.51% and the radiogenic argon represents 35.2 and 29.8% of the total argon in the samples BC and BD respectively (table 2).

The K<sub>2</sub>O content of individual glass shards measured under the electron microprobe yielded values ranging from 4.32 to 5.04%. It is thus

Table 1 Bulk chemical composition of tephra and local basalt

Component (%)	Tephra	Basalt
SiO <sub>2</sub>	75.07	51.0
Al <sub>2</sub> O <sub>3</sub>	6.40	19.77
Fe <sub>2</sub> O <sub>3</sub>	3.03	4.51
CaO	Nil	7.93
MgO	0.70	4.18
K <sub>2</sub> O	5.43	1.27
MnO	0.34	0.15

Table 2 K-Ar ages of the Bori ash samples

Sample	K* (%)	Radiogenic Ar (%)	Age (Myr)
BC	2.84	35.24	1.50 ± 0.25
BD	3.45	29.84	1.26 ± 0.23

\*Error in K determination is 2%.

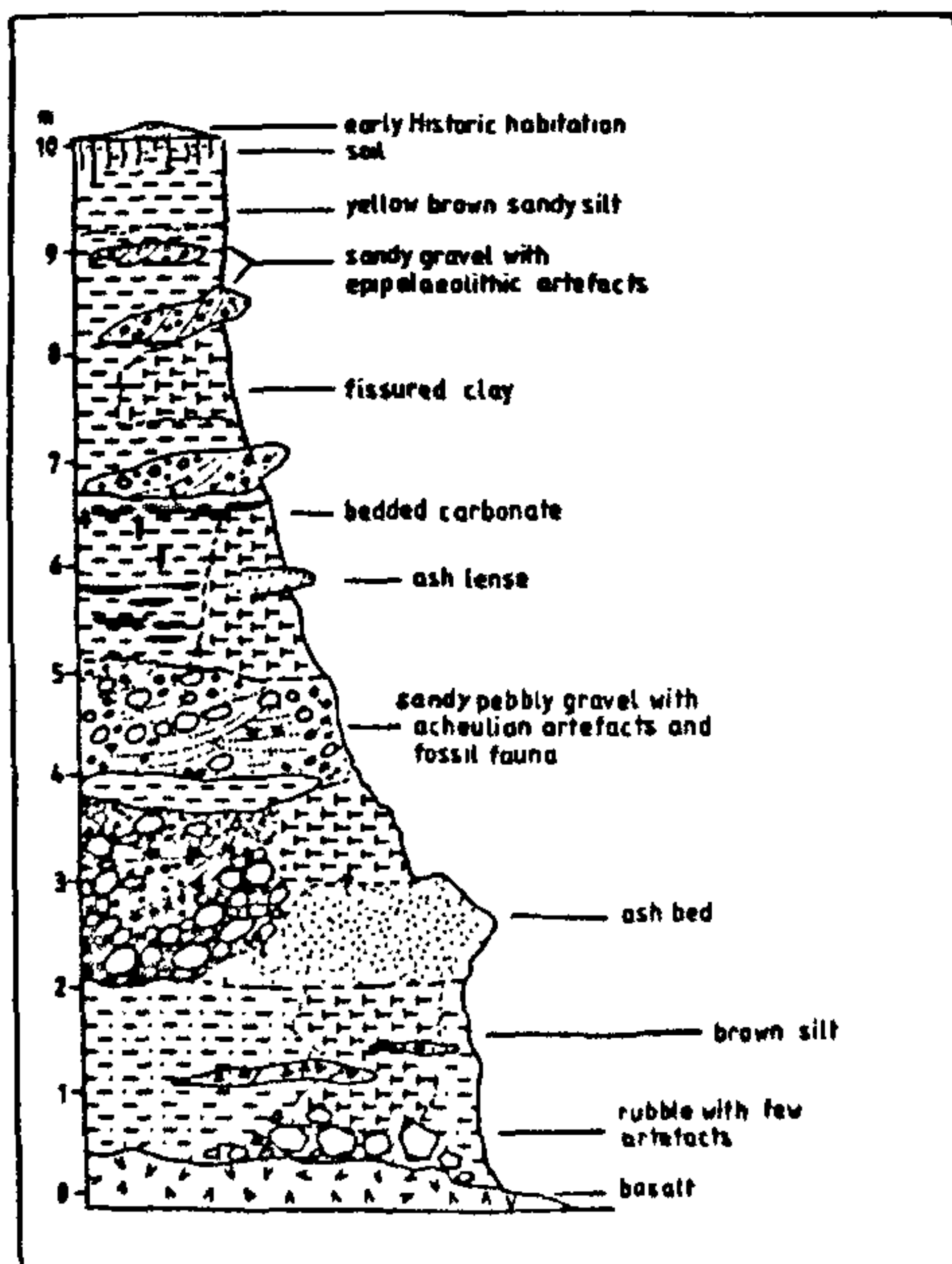


Figure 2. Composite lithostratigraphic profile from Bori.

inferred that the glass shards are enriched in K compared to the bulk samples.

U and Th isotopes and  $^{210}\text{Pb}$  by alpha spectroscopy<sup>2</sup> and  $^{226}\text{Ra}$  by radon emanation technique<sup>3</sup> were measured in the Bori ash. The results are given in table 3. Ideally, for a sample of age  $>1$  Myr, the daughter isotopes of  $^{238}\text{U}$  are expected to be in equilibrium, i.e. the isotopic activity ratios  $^{234}\text{U}/^{238}\text{U}$ ,  $^{230}\text{Th}/^{238}\text{U}$ ,  $^{226}\text{Ra}/^{230}\text{Th}$  and  $^{210}\text{Po}/^{226}\text{Ra}$  should be close to unity, the equilibrium value. The  $^{234}\text{U}/^{238}\text{U}$ ,  $^{230}\text{Th}/^{238}\text{U}$  and  $^{210}\text{Po}/^{226}\text{Ra}$  ratios are close to unity (table 3). Prehistoric and historic basalts from other regions were also found to have similar ratios<sup>4,5</sup>. However, the  $^{226}\text{Ra}/^{230}\text{Th}$  ratio is only 0.51, and needs explanation. Either  $^{226}\text{Ra}$ , an element known to be mobile, was lost to the water when the ash bed was inundated in the recent past ( $<5000$  yr), or the samples are quite inhomogeneous.  $^{226}\text{Ra}$  and  $^{230}\text{Th}$  were measured on separate samples whereas the rest of the isotopes were measured in the same sample. Such a  $^{226}\text{Ra}$  loss may be resulting in a K loss from the system, which can in principle result in older ages if the corresponding amount of  $^{40}\text{Ar}$  was not lost. The fact that the K-Ar ages of the samples BC and BD (table 2) are identical despite a 15% variation in their K content is encouraging and we propose to study the distribution of ages as a function of widely varying K contents.

Recently tephra occurrences have been reported from the Narmada valley<sup>6</sup> and Son valley<sup>7</sup>. These tephtras are also acidic in nature but have been placed in the Late Quaternary on the basis of

Table 3 U, Th decay series nuclides in the Bori ash samples

	Sample	
	BC	BD
Concentration		
$^{232}\text{Th}$ ppm	$28.10 \pm 3.20$	$32.90 \pm 3.10$
$^{238}\text{U}$ ppm	$4.43 \pm 0.53$	$4.40 \pm 0.16$
$^{230}\text{Th}$ dpm/g	$3.42 \pm 0.39$	$4.04 \pm 0.39$
$^{226}\text{Ra}$ dpm/g	NM	$2.08 \pm 0.06$
$^{210}\text{Po}$ dpm/g	NM	$1.73 \pm 0.06$
Activity ratio		
$^{230}\text{Th}/^{232}\text{Th}$	$0.49 \pm 0.01$	$0.49 \pm 0.01$
$^{234}\text{U}/^{238}\text{U}$	$0.98 \pm 0.01$	$0.99 \pm 0.01$
$^{230}\text{Th}/^{238}\text{U}$	$1.03 \pm 0.12$	$1.22 \pm 0.13$
$^{226}\text{Ra}/^{230}\text{Th}$	NM	$0.51 \pm 0.05$
$^{210}\text{Po}/^{226}\text{Ra}$	NM	$0.83 \pm 0.04$

Errors quoted are due to one-sigma-counting statistics only; NM. Not measured.

stratigraphic position. The Son valley tephra has been related to the Toba explosion in Sumatra dated to 80,000 yr<sup>8</sup>. Plio-Pleistocene bentonite tuffs have been reported from the Sub-Himalaya<sup>9</sup> and Kashmir basin<sup>10</sup>. The Bori volcanic ash, with a possible age of 1.4 Myr, provides an additional data point to the emerging record of Quaternary volcanic ash deposits of the Indian subcontinent.

Previous work on the Quaternary deposits in this area<sup>11</sup> distinguished two formations—a Late Pleistocene Upper Bhima Formation (UBF) and an Early Holocene post-Black soil Formation (PBF). On the basis of fluorine/phosphate ratio, dating of fossil bones, weathering of basalt pebbles and archaeological material, Mishra *et al*<sup>12</sup> suggested that an unconformity exists within the lower part of the UBF. In the absence of absolute ages of the lower members of the UBF, the time period represented by the disconformity could not be estimated. The tephra therefore serves as a dated marker bed and will be helpful in revising the stratigraphy of the region.

In summary, the discovery of this tephra layer is significant for the interpretation of the Quaternary depositional record of Peninsular India. It serves as a pointer to a more extensive record of Quaternary ash deposits in Peninsular India. Problems, however, remain in identifying the source(s) of the ash beds and also in establishing their relations in space and time.

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#### PROTEOLYTIC ACTIVITY OF A THERMOPHILIC STRAIN OF *NOCARDIA* SP. -TP8 ISOLATED FROM SOIL

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MICROBIAL enzymes, particularly the proteases, have wide-ranging applications in food, chemical, leather, medical, photographic and pharmaceutical industries. During the last few decades attention has been focused on the industrial production of enzymes from thermophilic micro-organisms because they are far superior to the enzymes from mesophiles by virtue of their higher thermostability. Losses are less during purification and due to the higher growth temperature of the organisms, industrial processes are beset with less fermentation contamination and, finally, no cooling costs<sup>1</sup> are involved.

Extracellular proteases are more abundant than intracellular proteases. The former are easy to detect and isolate and consequently they serve as important tools in industry and research<sup>2</sup>. There is extensive literature on production and properties of proteases from various micro-organisms such as

*Bacillus* sp.<sup>3-5</sup>, *Pseudomonas maltophilia*<sup>6</sup>, *Cephalosporium* sp.<sup>7</sup>, *Vibrio splendidus*<sup>8</sup>, *Vibrio harveyi*<sup>9</sup>, *Aspergillus* sp.<sup>2,10</sup>, *Mucor* sp.<sup>2,11</sup> and *Streptomyces* sp.<sup>11</sup>. We have come across a hitherto unreported thermophilic strain of *Nocardia* sp., which has a remarkable ability to produce an appreciable amount of extracellular protease. This paper describes the isolation and proteolytic activity of the thermophilic *Nocardia* strain.

The strain was isolated during an investigation to obtain a thermophile that could be exploited for production of extracellular protease on a commercial scale. Soil samples were collected from different parts of West Bengal. Colonies were isolated using dilution plating method under incubation at 45°C and transferred to nutrient agar slants. For the isolation of proteolytic strains, plates with nutrient agar (Hi-Media, India) containing gelatin (0.4%) were inoculated at the centre with strains isolated as above. After two days of incubation the plates were flooded with 12.5% mercuric chloride solution. Micro-organisms forming clear zones around their colonies were identified as protease producers. The zone of widest diameter was produced by a strain that was subsequently identified to be a thermophilic strain of *Nocardia* sp. The organism was designated as *Nocardia* sp. -TP8. The identification of the strain to the genus level was supported by the Commonwealth Mycological Institute, Kew, England.

One ml of cell suspension ( $6 \times 10^7$  cells) was inoculated into 100 ml flasks containing 25 ml of the medium. The medium contained 2.5% mannitol as the carbon source, 0.5% peptone as the protein source and 0.1% dipotassium hydrogen phosphate. Growth was found to be rapid in a rotary shaker at 45–47°C at an initial pH of 7.5, and after an incubation period of 24 h the culture filtrate was centrifuged at 10,000 r.p.m. for 15 min and the supernatant was utilized for assaying the enzyme.

Protease activity in the supernatant was evaluated by a modification of Anson's method<sup>12</sup>. The reaction mixture consisted of 1 ml of diluted supernatant and 1 ml of a selective protease inhibitor preincubated for 20 min at 37°C in a water bath. After preincubation 1 ml of casein solution in 0.4 M Tris-HCl buffer, pH 7.7, was added and the mixture was incubated for 30 min at 37°C in a water bath. The reaction was terminated by the addition of 3 ml of 5% trichloroacetic acid. The mixture was allowed to stand for 1 h and was then filtered. To 1 ml of the filtrate, 5 ml of 0.44 M Na<sub>2</sub>CO<sub>3</sub> and 1 ml of Folin reagent were added and absorbance at