The Deccan Basaltic Flood eruption is widely related to the northward drifting of the Indian Plate during the late mesozoic causing attenuation, warping and fracturing of the crust[1]. The main channel ways of eruption were located along the arms (Konkan arm with its northward extension — the Sabarmati graben, the Saurashtra arm and the Narmada arm) of the Cambay triple (and possibly a four-armed) junction and the lines of tension developed parallel to them[2].

The southern edge of the Malwa Plateau, south of Indore (22°43′ N: 75°50′ E) is rugged owing to the development of a number of narrow, vertically walled structural valleys roughly between Kannod and Gujri (22°25′ N to 22°75′ N: 75°25′ E to 76°75′ E). This has resulted in waterfalls of low height in the upper streams/nallahs.

These narrow, steep valleys are bounded on either side by vertical to steeply dipping faults, the individual valley varying in width from 15 to 20 m and visibly opening up to 40 to 110 m depth. Further, these valleys are characterized by the occurrence of peculiar breccias composed of heterogeneous fragments of various dimensions of vesicular, amygdaloidal and massive basalt set within an altogether different dark-coloured, fine-grained basaltic matrix. The confinement of these breccias only to the valley floor, heterogeneity of the enclosing basaltic fragments different from the ones exposed on the walls of valleys and their cross-cutting relationship are indicative of their being formed under confinement within the lithosphere principally by the process of quiet (auto) brecciation within a rising magma and due to commingling with the basaltic flows, it intruded. These breccias are referred to as "autoclastic volcanic (intrusion) breccias" in line with the classification of volcanic breccias advocated by Fisher[3].

Occurrence of these autoclastic volcanic breccias was noted in all the three valleys investigated, viz., Tincha (22°34′ N: 75°59′ E), Kajligarh (22°31′ N: 75°57′ E) and Khudel. The area is mainly drained by Kaner nallah which on its southward journey joins the Choral river, a tributory of the Narmada.

Subramanyan[4], while describing the geomorphology of the Deccan Volcanic Province, remarks: "The small hanging valleys with short waterfalls of some of the southerly tributaries to the Choral river in the central part and the many waterfalls further to the north are suggestive of progressive east-west step-faulting with southerly down-throws parallel to the Narmada". However, the present investigation revealed that these structural valleys originated owing to a combination of "volcano-tectonic processes" (tectonically controlled subsidence valleys resulting from the outpouring of magma from its chamber followed by caving in of overlying crust) and perhaps mark the subsidiary channelways of Deccan eruptions as lines of tension developed north of "ENE–WSW trending Narmada graben".

The author is grateful to Prof. B. K. Nilosey, Principal, Holkar Science College, Indore, for his constant encouragement and to Professors A. Y. Kashkhedikar, V. L. Punwatkar, S. K. Chaure and R. S. Raghuwanshi for accompanying on various field trips.

11 September 1987; Revised 18 December 1987

1. Ghose, N. C., *Rec. Geol. Surv. India*, 1983, **113**, 86.
2. Powar, K. B., *Everyman's Sci.*, 1987, **22**, 32.
3. Fisher, R. V., *Bull. Geol. Soc. Am.*, 1960, **71**, 973.
4. Subramanyan, V., *Mem. Geol. Soc. India*, 1981, **3**, 113.

ON THE AGE OF THE LOWER COARSE MEMBER OF THE UPPER BHIMA FORMATION

V. S. KALE, N. J. PAWAR, T. C. ATKINSON* and P. J. ROWE*

School of Environmental Sciences and Department of Geography, University of Poona, Pune 411 007, India.
** School of Environmental Sciences, University of East Anglia, Norwich, UK.*

THE Upper Bhima Formation (UBF) is the most ubiquitous alluvial formation in the Upland region of the Deccan Volcanic Province[1]. Although more than a dozen radio-carbon (^{14}C) dates are available from the upper fine member of UBF, the basal coarse member of the formation is beyond the range of ^{14}C dating and therefore could not be dated in absolute terms. Earlier workers have tentatively assigned a late-middle Pleistocene date on the basis of archaeological, geomorphological and palaeontological evidence[2].

Therefore, the uranium series disequilibrium dating method was applied to a fossilized tusk of an *Elephus* sp.[3] from Yedurwadi, Karnataka (figure 1). Analysis of the bone shows that the percentage of fluorine and phosphate (F & P_2O_5) are, respectively, 0.636 and 14.31 (Kshirsagar, personal commun.). An activity ratio of 0.543 between ^{230}Th

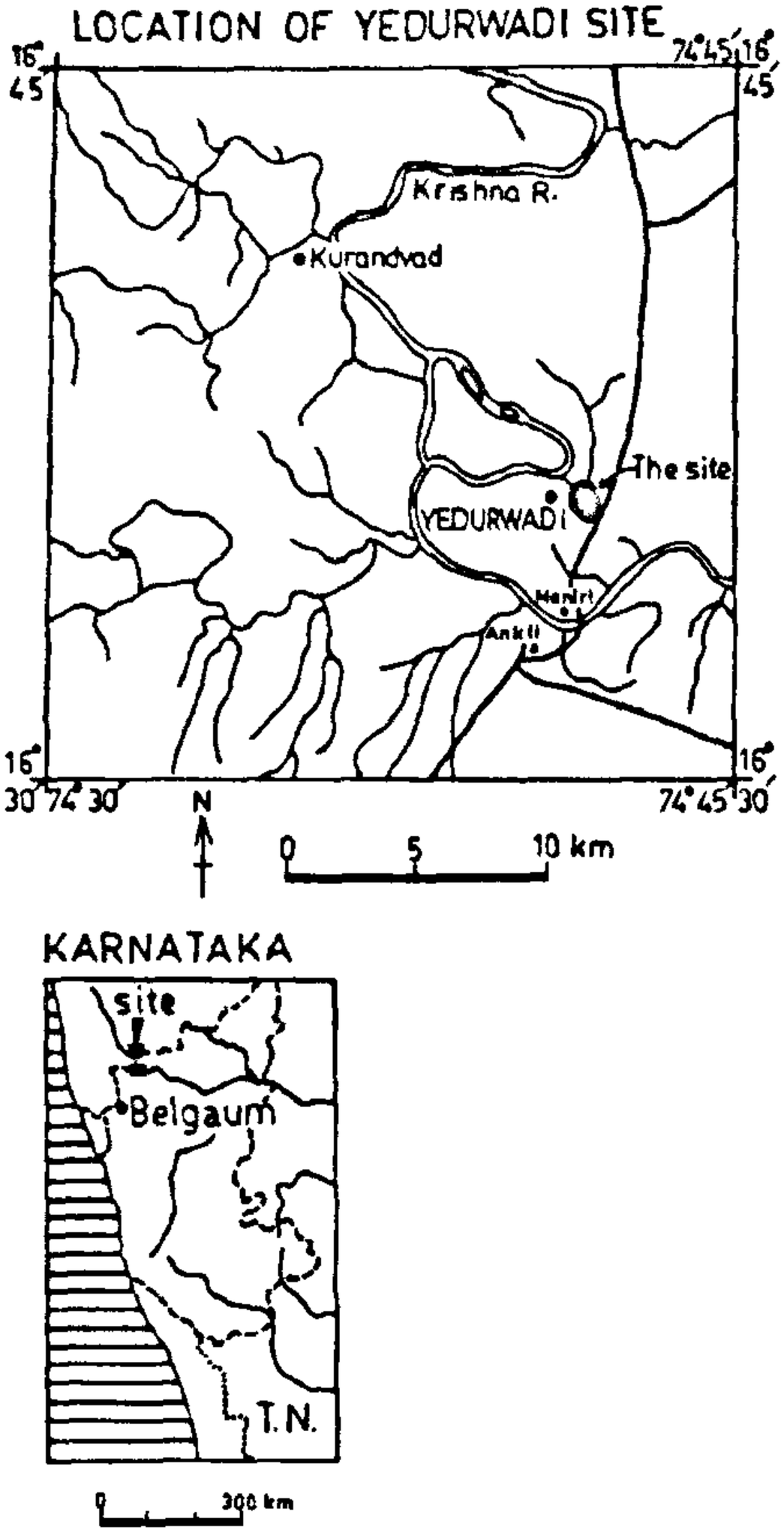

Figure 1. Location of the Acheulian site on the link-channel of river Krishna.

and ^{234}U was obtained, which gave a thorium age of $81{,}000 \pm^{4200}_{4000}$ yrs BP (UEA-237) for the tusk. In this case, a correction was applied to $^{230}Th/^{234}U$ to get a truer estimate of the age, by using $^{230}Th/^{232}Th$ ratio. The date is useful in approximating the age of the basal gravel of the UBF. Because of the low yields of ^{234}U and ^{230}Th and the fact that uranium uptake in bone occurs only after the animal's death, this date is provisional and must be interpreted cautiously. Nevertheless, the date suggests that the tusk, along with the litho-unit containing it, belongs to the last interglacial period (stage 5 e). This inference is consistent with the relative geomorphological position of the site on a low terrace of the link-channel of river Krishna and synchronizes well with the relative dates based on fluorine-phosphate ratio of the dated tusk and other fossils from the same horizon.

The fluorine-phosphate ratio (F & P_2O_5) provides a good measure of determining the relative age of fossils, present in similar lithostratigraphical situations, from other valleys of the Deccan Trap region. A collation of the (F & P_2O_5) value of the Yedurwadi tusk (4.44; Kshirsagar, personal commun.) with the ratios of bones from comparable sites, viz., Chirki Nevasa (8), Inamgoan (5)[5], Bori (5–7; Kshirsagar personal commun.), etc. implies that the latter fossil fauna are much older than the dated tusk. In other words, a major portion of the exposed basal gravel of the UBF and the associated Acheulian artifacts predates the Yedurwadi tusk and is therefore undoubtedly older than 100,000 years. The age is in good agreement with the age of the Lower Palaeolithic industry (69–190 k yr BP) obtained for the Hiran valley, Saurashtra[6].

The inference tentatively establishes the antiquity of the Quaternary formations as well as the Acheulian tools from this part of the Deccan for the first time.

The authors thank the British Council and the UGC, New Delhi, for supporting the academic link under which this work was carried out and Professor S. C. Gupte for providing facilities.

10 October 1987; 16 March 1988

1. Kale, V. S. and Rajaguru, S. N., *Nature (London)*, 1987, **325**, 612.
2. Rajaguru, S. N. and Kale, V. S., *J. Geol. Soc. India*, 1985, **27**, 16.
3. Kale, V. S., Ganjoo, R. K., Rajaguru, S. N. and Salahuddin, *Curr. Sci.*, 1986, **55**, 1073.
4. Ivanovich, M. and Harmon, R. S., (eds), *Uranium series disequilibrium: Application to environmental problems*, Oxford, Clarendon, 1986.
5. Joshi, R. V. and Kshirsagar, A. A., *Fluorine and other chemical studies of quaternary animal fossils of India*, Deccan College Publication, Pune, 1986.
6. Baskaran, M., Marathe, A. R., Rajaguru, S. N. and Somayajulu, B. L. K., *J. Achaeol. Sci.*, 1986, **13**, 505.