to differentiate the Philippine strain from the Malaysian ones on the basis of the isoenzymic patterns of GDH and MDH. These strains have also been differentiated earlier on the basis of LDH isoenzymes[7]. Differences in the circumsporozoite protein genes of the two strains (P and H) were also observed[17]. These findings suggest that the parasites from the two different geographical regions are genetically different and possess distinct isoenzymic pattern. Carter also differentiated subspecies of murine malaria by isoenzymic studies on MDH and GDH[4,5].

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## RADIOACTIVE DINOSAUR BONES

U. B. MATHUR
*Regional Palaeontological Laboratory, Geological Survey of India, B-201, Rajendra Marg, Bapu Nagar, Jaipur 302 015, India.*

DINOSAUR bones[1-4], teeth[5] and eggs[6-9] are found in Cretaceous-? Palaeocene[10,11] Lameta sediments of Kheda and Panchmahal districts of Gujarat. During a recent study of dinosaur bones from Rahioli area (figure 1) in the Balasinor taluk of Kheda district, Gujarat, the present author found them to be highly radioactive. So far there is no record of high radioactivity in either the Lameta sediments or in other dinosaur fossils of India. The U content in the dinosaur bones from Lameta sediments from Umrer (Nagpur) and Jabalpur ranges between 66 and 246 ppm[12]. However, the mammalian fossils in the Upper Siwalik Formation of Pinjor Himalaya are known for noticeable concentration of uranium[13-15] (0.05–0.34% $U_3O_8$ with no thorium). Outside India, the dinosaur bones from Morrison Formation (Jurassic) of Camp Davies Region, Western Wyoming (USA) are also known for their radioactivity[16] (0.04–0.12% $U_3O_8$). The presence of radioactivity in the dinosaur bones of Lameta sediments is of great significance as it may serve as a guide for locating deposits expected to contain radioactive mineral in commercial quantity. So far, the only other sedimentaries which are time contemporaneous to Lametas and also known for uranium concentration are the Mahadeo (Mahadek) Formation of Khasi and Jaintia hills of Eastern India[17,18].

The uraniferous dinosaur bones were collected from the eastern slope of a north-south trending hillock, about 1 km west of Rahioli village. In this area, the sedimentary sequence comprising greenish conglomerates/grits, greenish grey, medium to fine-grained calcareous sandstone and fine-grained, mottled to purplish arenaceous limestone belong to Lameta Group (figure 1). The sedimentaries overlie the Precambrian Godhra granite and pegmatite. The Deccan Trap volcanics which overlie the Lameta sediments elsewhere, have been eroded in

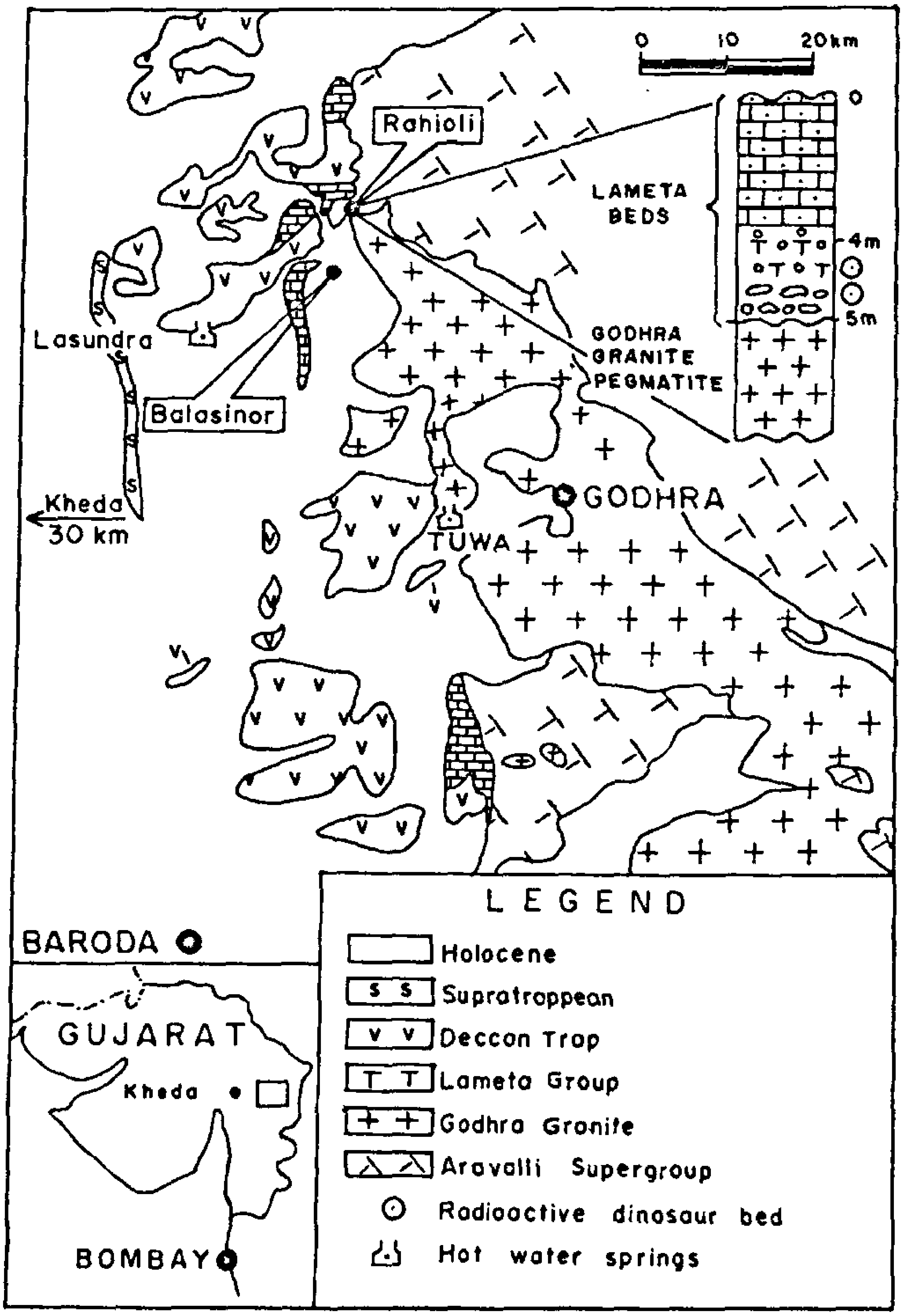


**Figure 1.** Geological map of a part of Kheda-Panchmahals districts, Gujarat showing radioactive dinosaur fossil locality and hot water spring.

the study area, but their effect in the form of extensive chertification of the infratrappean Lameta sediments can be seen. Besides, a thin veneer of red soil, derived presumably from the weathering of Deccan Trap, covers the Lameta sediments.

A large number of dinosaur long bones, vertebrae, etc. were tested for their radioactivity with Geiger Muller counter. They showed radiation counts higher than the background counts. Subsequently, semi-quantitative estimates were made spectrographically at the GSI, Chemical Laboratory which show that the long bones contain 300–700 ppm U with thorium below detection limit. These fossil bones also contain up to 30% $P_2O_5$. The uraniferous phosphatic fossil bones also contain Mo, Ni, V, Mn and other metals. In contrast to the high radioactivity of the dinosaur bones, their matrix is non-radioactive.

The radioactivity of the dinosaur bones appears to have been caused by the replacement of phosphatic ions of the fossil bones by uranium derived from the groundwater percolating in the area. At the same time, the Lameta sediments of the study area do not contain lithic elements like carbonaceous matter/sulphides, etc. which could have produced reducing conditions in favour of deposition of radioactive minerals from the radioactive waters. This explains the absence of localization of radioactive minerals in the ossiferous sediments of the area. They might have, however, localized elsewhere depending upon the presence of suitable agents for reducing uranium and other radioactive minerals.

As regards the source of radioactive minerals, a critical look at the geology of the area and its vicinity is required at the first instance. The granites and pegmatites, over which the ossiferous sediments lie, could have themselves been the source of mineralization. At present there are no indications to show that such was the case. However, radioactive Tuwa hotwater spring (30 km from the study area) is located in pegmatite. Thus, the possibility of pegmatites being the provenance for recycling of uranium cannot be ruled out. An alternate source for radioactive waters could be the acid igneous rocks of Deccan Trap Formation. The highly oxidizing conditions present during the post-trappean period could have oxidized the uranium which was subsequently substituted in the apatite lattice of the dinosaur fossil bones.

Further conclusions concerning the origin of radioactivity in dinosaur bones and extent of radioactive-bearing beds cannot be drawn unless detailed investigations are carried out. Occurrence of uranium in dinosaur bones may merely be a local phenomenon or there may be several deposits in the vicinity. The answer to this question lies in further work. The present author is, however, inclined to believe that the presence of high radioactivity in dinosaur bones of Rahioli area opens up a new area for the search of radioactive minerals in Western India.

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## MIDDLE KROL STROMATOLITES FROM THE NAINITAL AREA, KUMAUN LESSER HIMALAYA

C. C. PANT and A. K. SHARMA
*Department of Geology, Kumaun University, Nainital 263 002, India.*

THE Middle Krol is a well-marked horizon of the Krol Belt extending over 300 km from Solan (HP) in the west to Nainital in the east. In the Nainital syncline (table 1) it comprises maroon shales, marl and siltstone with lentiform biohermal dolomitic limestone showing a variety of sedimentary structures such as small-scale cross laminations and wave and current ripples. An assemblage of well-developed stromatolites from the Middle Krol in the Balia nala and Nihal section has been identified (figure 1).

Stromatolites from the Sherwood Member of the Upper Krol have been described earlier[1–4] and their age assignment varies from Precambrian to late Palaeozoic[5]. However, Misra[4] attributed the varied