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Collection of ESR samples from the interior of mammoth teeth causing minimal damage

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Uranium uptake into fossil bones and teeth constitutes a major problem in ESR dating. The actual process of U-uptake is not well known and the uncertainty of ESR age estimates is proportional to the amount of uranium in the samples analysed (see e.g. Grün and Stringer, 1991). Fission track maps of mammoth/elephant molars have shown that most of the accumulated uranium is fixed in the outer layers of the specimen (Grün and Invernati, 1985). This allows us to collect samples from the interior of the teeth which have low U-concentrations and, hence, the uncertainty in the ESR age estimation caused by the unknown U-uptake is rather small. Mammoth molars are one of the few materials that are useful for dating of fluvial sediments, although their frequency in those sediments is variable. The sampling strategy has led to the successful dating of various Quaternary sites, such as the Saskatchewan Sands and Gravels, Canada (Grün et al, 1987), the Balderton Sands and Gravels, England (Grün, 1991) or the interstadial site of Agnadarrah, N. Ireland (Grün et al. in prep.).

For the extraction of the ESR samples in early studies, the molar was cut in half with a diamond saw and a sequence of successive enamel and dentine/cement samples was cut out of one of the halves. During the extraction process the tooth was severely damaged (see e.g. Grün, 1989, Photo 5) and it was usually not possible to reconstruct it afterwards. Although this method was entirely satisfactory from an ESR point of view, only a few zoologists, museum curators or collectors were willing to part with precious specimens for ESR dating and, hence, many Quaternary sites could not be dated.

Our first attempt to limit the damage to the teeth was by the use of diamond corers. The problem with coring is the structure of the mammoth tooth itself: hard layers of enamel alternate with very soft layers of dentine or cement. For the drilling of the enamel the diamond corer has to be water-cooled otherwise the diamonds would become unfastened. It was found impossible to drill through a tooth without breaking the enamel layer off the organic layers and usually only a mix of broken pieces could be extracted. With such samples it was difficult to determine the beta dose rate exactly. Additionally, there was no "plug" of tooth material to seal the drilled hole after extraction.

The second technique tested was the use of a Well 6234 precision diamond wire saw (D.R. Bennett, Ltd). The kerf produced by the wire is very narrow, only about 0.5 mm. About a quarter of the tooth is cut at a very slow rate of about 1 cm/hour. The cut starts from the roots towards the top and then runs to the outside. This leaves the occlusal (chewing) surface intact, which is essential as this is the zoologically diagnostic part of the tooth. ESR samples can now be extracted with a hand held dentists' diamond drill (Figure 1). The two cut segments can be glued together without major visible damage to the exterior of the molar.

We hope that the application of this technique will allow in the future to date many Quaternary sites, which are presently undated because of the reluctance to sacrifice valuable museum pieces for the dating procedure.

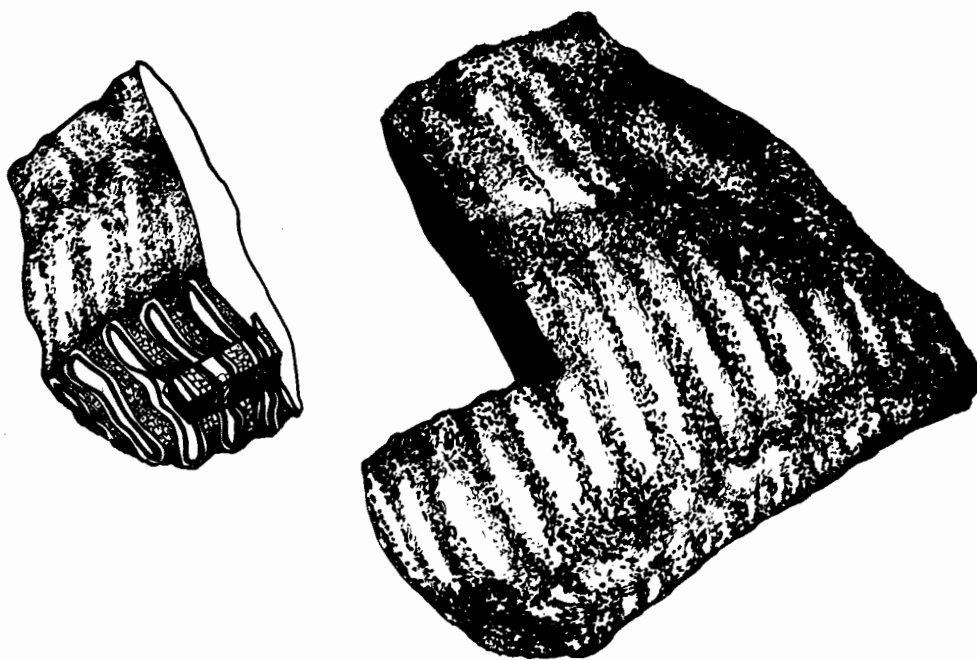


Figure 1.

Cut mammoth tooth. ESR samples were extracted from the top of the quarter.

Acknowledgement

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This is sound advice for the preparation of ESR samples from elephant teeth. The equipment described (Well precision diamond wire saw) is not, however, generally available and is a very expensive piece of equipment. A satisfactory substitute is a diamond-blade band-saw, such as can be found in shops which prepare decorative mirrors and glass table-tops, etc. We have found it possible to make use of such equipment for the same purpose. The kerf of the diamond band-saw is of the order of 1mm or less, and cutting does not cause splitting of the tooth.