In situ U-series microanalysis of fossil human remains

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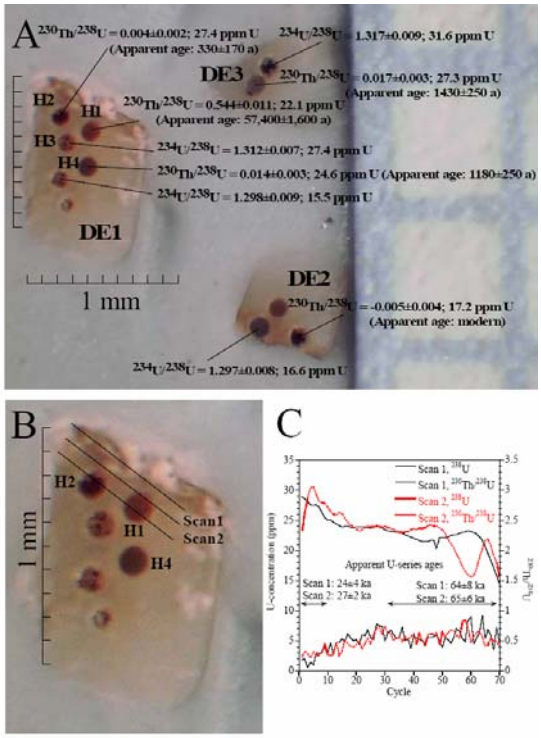

When dating human remains, it is necessary to keep any destruction to an absolute minimum. During an ESR dating study on the Neanderthal Banyoles mandible, it was necessary to analyse the U-series isotopes on dentine adjacent to the enamel piece that had previously been analysed by ESR. We were able to obtain three small dentine fragments (DE1 to DE3), the largest had a maximum dimension of 1 mm (Figure 1). These were analysed for U-series isotopes by drilling holes with the laser (see Figure 6A) and subsequent analysis with the Neptune multicollector ICP MS. Because of the configuration of the Neptune with a single central ion counter, this can either be used for the measurement of ^{234}U or ^{230}Th. Thus the material ablated from the holes give either ^{234}U/^{238}U or ^{230}Th/^{238}U ratios. The ^{234}U/^{238}U ratio is very homogeneous, four measurements yielding a mean of 1.306±0.009 (1-σ s.d.). In contrast, the ^{230}Th/^{238}U ratios and the U concentrations varied greatly: the ^{230}Th/^{238}U ratio between virtual background and 0.544±0.011, and the U-concentration between about 15.5 and 32 ppm. The large variation of the ^{230}Th/^{238}U values is astonishing, particularly considering that the high U-concentrations and the extremes measured on the material ablated from holes H1 and H2 in dentine fragment DE1 are less than 0.2 mm apart. Because of the surprising small scale variation in the ^{230}Th/^{238}U values, two laser ablation scans were run across the top of DE1 in the same track (the second scan ablating material from deeper into the sample). The approximate positions of the scans are indicated in Figure 1B. Note that the three-dimensional symmetry of the sample is somewhat different than can be estimated from the surface shown in Figure 1B. The first scan did not penetrate either of holes H1 and H2, while the second scan ran completely through H1 (causing the apparent drop in U-concentration in Scan 2; see Figure

1C) and just the top of H2. It can be clearly seen that the U-concentrations increase from H1 to H2, while the $^{230}Th/^{238}U$ values decrease, confirming the observations made from the holes. The average U-concentration of the dentine is 24±5.5 ppm. Because of the small-scale variations in the $^{230}Th/^{238}U$ ratio, it is difficult to estimate an average $^{230}Th/^{238}U$value for the dentine. All results below 0.5 mm below the surface (i.e. hole H4 and below) and the other two dentine fragments, whose exact spatial relationship to DE1 cannot be reconstructed, correspond to U-series ages of younger than about 1400 years (apparent U-series age on DE3).

The dentine clearly underwent at least two U-accumulation stages, one several tens of thousands of years ago, possibly during the initial burial phase, and a second one, perhaps starting about 1400 years ago and continuing to very recent times. This later U-accumulation phase was most likely initiated by the activation of percolating waters from historic quarrying and drainage activities. In 812, Abbot Bonitus founded the monastery of Sant Esteve on what was then waste land. To control the level of the lake, the monks laid a network of irrigation ditches which turned an uninhabitable place into an agricultural and industrial area which would soon become prosperous. In the 13th and 14th centuries, the area underwent great expansions with the establishment of varied industries.

With conventional analytical techniques we may have been able to obtain one single U-series result on the combined dentine. The micro analytical capabilities of the laser ablation system do not only allow repeated, detailed analyses of the material, they also give hitherto unobtainable insights into the mechanism of U-migration in dental material.