Can spectroscopic methods distinguish forensic and archaeological human skeletal remains?

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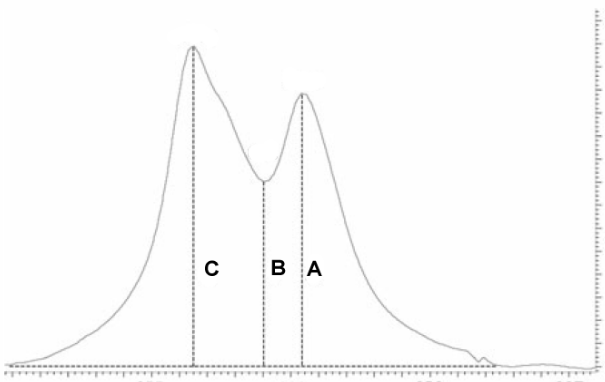
Dating skeletal human remains and distinguishing between forensic and archaeological material is a vital task both in jurisdiction and archaeology. Beneath others, spectroscopic methods (FTIR and Raman) have been suggested and are widely used to answer these questions.

FTIR spectroscopy

Patonai et al. (2012) proposed a "crystallinity index" calculated after Weiner and Bar-Yosef (1990), derived from adding heights of the absorptions at approximately 605 and 565 cm^{-1} and then dividing by the height of the minimum between them. Band component analysis (this work) shows that the two supposed "peaks" in fact are composed of at least five bands. Their correlation cannot be given in a formula like A+C/B = CI, as proposed by Patonai (2012) and Weiner and Bar-Yosef (1990).



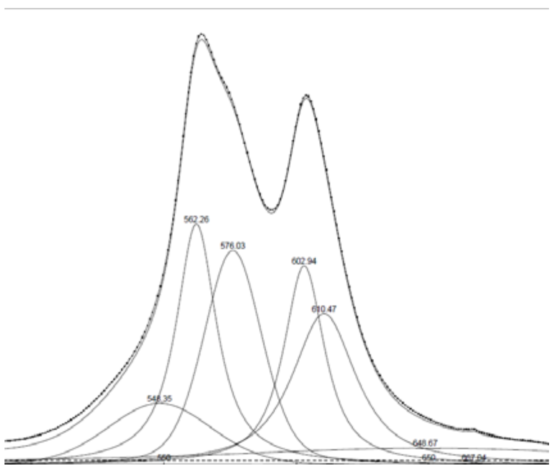
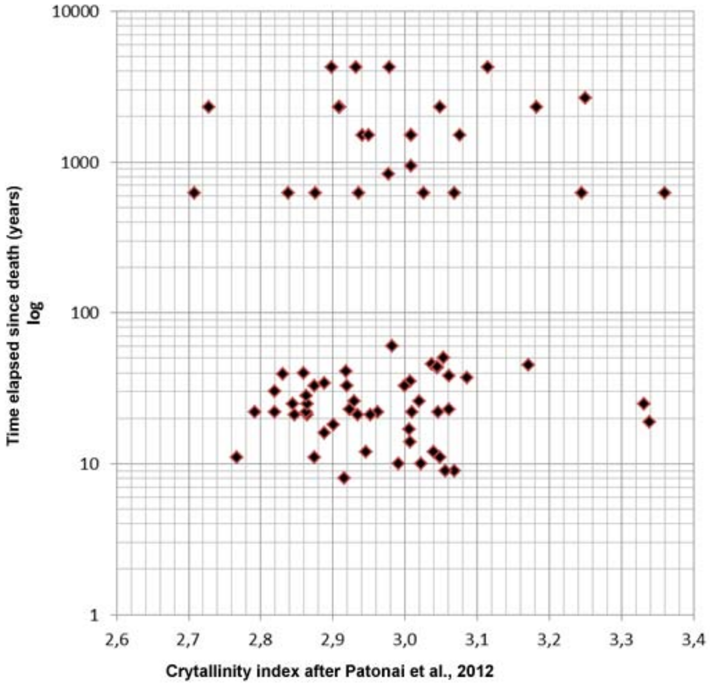


Fig. 1.*(left): Calculation of the so called crystallinity index (CI) after Patonai et al., 2012.*
Fig 2. *(right): Band component analysis of the area used by Patonai et al., 2012, for calcu-lating their crystallinity index (this work, sample MP59, late Middle Ages, 1300 to 1500 AD).*

Nevertheless the method was tested with a cohort of more than one hundred samples (forensic as well as archaeological material). In the context of a larger project investigating the diagenetic mechanisms affecting bone material 50 human femora from a modern Munich cemetery (time elapsed since death was eight to 60 years) were analyzed supplemented by a similar number of archaeological bone material (stone age to middle ages).

Whereas the archaeological material comes from many different places with different soil parameters the modern material comes all from the same cemetery and these bones have all been embedded in the same soil and all endured the same climate. To prevent possible differences in crystallinity between different skeletal elements, only femora were used for all analyses. The results (see Fig. 3) showed that even with an identical age the crystallinity index varies in a wide range. This applies to archaeological material as well as to the modern material from Munich cemetery which is exactly dateable.



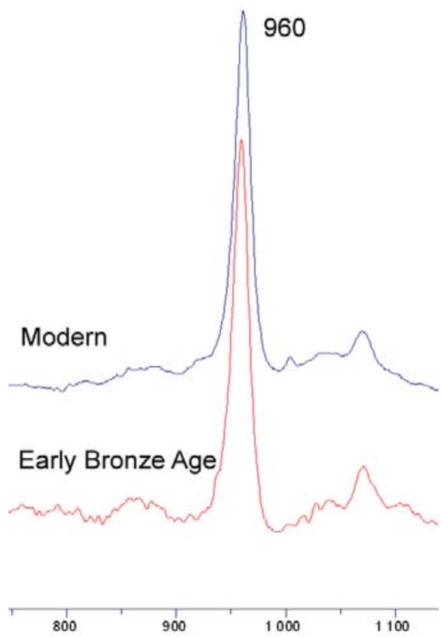


Fig. 3. *(left): Correlation between crystallinity index (FTIR) and time elapsed since dead.*
Fig. 4. *(right): The band of the symmetric stretching vibration of the PO_4^{3-} -group in bone apatite, commonly used for quantifying the crystallinity index (Raman).*

Raman spectroscopy

A Raman crystallinity index has been proposed by different authors (for instance Penel et al., 1998; Freeman et al., 2001), using the frequency and the full width at half maximum of the peak of the symmetric stretching vibration of the PO_4^{3-} group. Pucéat et al. (2004) already showed by analyzing biogenic apatites that this index cannot be used to distinguish between fresh and altered bone material. Investigations during this work showed that there is no correlation between crystallinity index (Raman) and age. In Fig. 4 two spectra of bone apatite from a modern skeleton and a skeleton from the Early Bronze Age respectively are shown which display a nearly identical index despite an age difference of more than 2000 years.

References:

Freeman JJ, Wopenka B, Silva MJ, Pasteris JD (2001) Raman spectroscopic detection of changes in bioapatite in mouse femora as a function of age and in vitro fluoride treatment. Calc Tiss Res 68:156–162

Patonai Z, Maasz G, Berthoin S, Avar P, Schmidt J, Lorand T, Bajnoczky I, Mark L (2012) Novel dating method to distinguish between forensic and archeological human skeletal remains by bone mineralization indexes. Int J Legal Med 127:529–533

Penel G, Leroy G, Rey C, Bres E (1998) MicroRaman spectral study of the PO_4 and CO_3 vibrational modes in synthetic and biological apatites. Calc Tiss Res 63:475–481

Pucéat E, Reynard B, Lécuyer C (2004) Can crystallinity be used to determine the degree of chemical alteration of biogenic apatites? Chem Geol 205:83–97

Weiner S, Bar-Yosef O (1990) States of preservation of bones from prehistoric sites in the Near East: A survey. J Archaeol Sci 17:187–19