age reversals and compressed time periods in the archaeological and geological record. Until such time as corroborative records become available, we consider our spline to be a 'comparison' curve in line with recommendations by van der Plicht (2001), and do not recommend use of our data for calibration purposes until confirmation of the timing and magnitude of variation is confirmed by independent data. Our record does, nevertheless, suggest that there are many more surprises in store for us in this rapidly developing field.

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PAUL PETTITT kindly introduces the significance of a second note on recent developments in ^{14}C dating:

'One of the major limitations of ^{14}C dating is the unreliability of measurements on the bones in which collagen preservation is low, either through diagenesis or combustion. Certainly, as Aertz *et al.* suggest with their dating of "burnt collagen" from burials at Sanaigmhor Warren, Islay, measurements on this organic fraction are usually underestimates. Assuming that the team have undertaken a good number of measurements on samples that they can cross-check with independent means of ascertaining the age of the samples, whether by dating of associated charcoal or through ceramic style, this new development, facilitating the measurement of carbon in structural carbonate at the Groningen Centre for Isotope Research, is a major breakthrough in measurement methods.

'Because carbonate preservation in these samples is low, i.e. around 10%, the sample size required for this technique, ~1·5 g, is large by AMS standards. Presumably though, this will present no problems with samples of cremated bone which are of limited anatomical and palaeopathological value, and as the authors suggest even particulate bone can be used, thus allowing the preservation of more intact bones from cremation deposits. In any case, sample size is certainly outweighed by the advantages of being able to date a large sample set previously unavailable for dating with any degree of confidence. This is very good news — for later prehistorians in particular, and a welcome example of how ^{14}C dating continues to be developed in internationally respected laboratories.'

Radiocarbon dates on cremated bone from Sanaigmhor Warren, Islay

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One of the most interesting and immediately useful developments in radiocarbon dating for archaeologists in recent years has been the discovery that cremated bone can be easily and very successfully dated. That it might be possible was recognized in late 1998 and tested extensively in the following 12 months. It is now abundantly clear that cremated bone provides a highly reliable material for radiocarbon dating (Lanting *et al.* in press)

Bone consists of long chains of proteins (collagen) in which particles of poorly crystallized inorganic material are embedded. The inorganic material is primarily a calcium phosphate with an apatite-like structure ('bio-apatite'). A unique feature of this bio-apatite is that it includes some carbonate ions by substituting phosphate ions

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in the crystal lattice. This so-called structural carbonate has its origin in blood bicarbonate generated by energy production in the cells. It is therefore directly related to the food consumed by the individual or animal in question.

Previous attempts at dating cremated bone failed chiefly because it was treated as burnt bone, i.e. bone heated at relatively low temperatures (200–300°C) which still retains carbonized fats and proteins. The carbonized compounds are easily contaminated by absorbed humic substances, however. Cremated bone has been heated at higher temperatures, at least 600°C, and contains no carbonized material at all. One of the reasons why cremated bones survive even in acid soils is that at temperatures above 600°C the bio-apatite recrystallizes and larger, better-structured crystals are formed. On the assumption that it was unlikely that all structural carbonate would disappear on a prehistoric pyre, the Groningen Centre for Isotope Research was asked to date a number of prehistoric cremations using this structural carbonate. In order to judge the carbonate dates, the cremations chosen had all been previously dated on charcoal found amongst the cremated bones.

The results demonstrated conclusively that cremated bone does retain sufficient carbonate for dating purposes, although up to 90% may disappear during the cremation process. This results in a shift of $\delta^{13}C$ in structural carbonate from about –15‰ in unburnt bone to between –20‰ and –30‰ in burnt bone due to isotopic fractionation and makes cremated bone unsuitable for palaeodiet studies. It does not influence its 'datability', however. Since the initial tests, some 400 cremations have been dated using the technique. For a full account of the technique, see Lanting *et al.* (in press), and for an interim report on the results of some Iris cremations, see Lanting & Brindley (1998).

As little as 1·5 grammes of cremated bone is required for dating by AMS. This does not have to be solid bone; tests have shown that small particles produce the same results.

In the most recent volume of the *Proceedings of the Society of Antiquaries of Scotland* is a report on the excavation of two burials at Sanaigmhor Warren, Islay (Cook 1999: 251–79). The burials formed part of a number of archaeological features uncovered and threatened by destruction after a blow-out formed in the machair. The features excavated were a cist, two cairns and a dyke (Cook 1999: illustration 2). Cist A consisted of a rectangular setting of four side stones (0·60x0·70 m) in a pit. Covered by a flagstone was a cremation contained in a simple, undecorated and somewhat rough urn (Cook 1999: illustrations 4 & 7). Cairn B was a 'loose scatter of stones measuring 6 m x 5 m', below which an undecorated urn containing a cremation was found (Cook 1999: illustrations 5 & 7). The two burials were dated using 'carbonized collagen' from insufficiently burnt bone, still black in some places, with the following results:

Cist A	AA-26244	1655±50 BP	$\delta^{13}C$ = –24·31‰
Cairn B	AA-26243	2300±50 BP	$\delta^{13}C$ = –24·51‰

Our attention was drawn to the results by our interest firstly in radiocarbon dating and secondly in the dating of Bronze Age pottery from Great Britain and Ireland. Both dates are much younger than expected while the $\delta^{13}C$ does not fit with values usually obtained for collagen, suggesting that in fact mixtures of carbonized collagen and humic matter had been dated.

Two samples of white, fully calcined, cremated bone were obtained from the excavator, M. Cook, and were dated in Groningen. The results are as follows:

Cist A	GrA-17598	2720±40 BP
Cairn B	GrA-17600	2620±40 BP

A glance at the calibration curve shows that these dates indicate absolute dates between 800 and 900 BC which confirm R. Cowie's identification of the pottery as Late Bronze Age vessels (pottery report in Cook 1999: 260–66).

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