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LETTER TO THE EDITOR

Evidence from Uranium-Series-Dated Speleothems for the Timing of the Penultimate Deglaciation of Northwestern Europe

Over the past two decades hundreds of speleothems from caves in northwestern Europe have been dated by the uranium-series method. These data and deposits have the potential to provide new continental-based information regarding the start of the penultimate deglaciation, a much debated topic (Karner and Muller, 2000; Gallup *et al.*, 2002).

That speleothems are unlikely to form in regions overlain by, or peripheral to, ice sheets has been noted in several studies (Atkinson *et al.*, 1986; Gascoyne, 1992; Gascoyne *et al.*, 1983; Gordon *et al.*, 1989; and Lauritzen, 1993). High $p\mathrm{CO_2}$ waters of soil-zone origin and vadose recharge are mandatory for the formation of speleothems. Thus, in regions overrun by ice sheets, or in periglacial areas, speleothem growth ceases due to one or more of the following reasons: (a) the soils have been stripped away; (b) there is no groundwater recharge owing to the ice sheet or to permafrost; (c) soils survive, but vegetation is minimal; or (d) the cave has been flooded due to blockage of drainage by an ice sheet or valley glacier.

Histogram and growth-frequency analyses of hundreds of speleothem ages from northwestern Europe show little or no speleothem growth during times corresponding to MIS (marine isotope stages) 6 and 2, but abundant growth during the last and present interglacial intervals (Gascoyne *et al.*, 1983; Baker *et al.*, 1993; Lauritzen, 1993). Intermediate growth occurred during interstades. Specifically, from a growth-frequency analysis, Baker *et al.* (1993, Table 2) reported significant speleothem growth between 133,000 and 115,000 yr B.P. Detailed studies of individual speleothems support Baker *et al.*'s (1993) finding of active speleothem growth as early as 133,000 years ago. Gascoyne *et al.* (1981) dated the famous Ipswichian "hippopotamus fauna" in Victoria Cave, in the central United Kingdom. These fauna were entombed in dense flowstone ranging in age from $135{,}000 \pm 8000$ yr (1σ) B.P. at the base of the deposit to $114{,}000 \pm 5000$ yr (1σ) B.P. at the top. In Norway, studies by Lauritzen (1995) and Berstad *et al.* (1997) indicate, respectively, that speleothem growth was underway near the Arctic Circle as early as $\sim 145{,}000 \pm 5000$ yr (1σ) and $\sim 144{,}000 \pm 11{,}000$ yr (1σ) B.P. In all of the above-cited studies, the speleothems were dated using the alpha-spectrometric (AS) uranium-series methodology. Using the more precise thermal-ionization mass spectrometric (TIMS) uranium-series dating, Baker *et al.* (1995) obtained an age of $\sim 133{,}000 \pm 2400$ yr (2σ) B.P. for the base of a speleothem from Yorkshire, United Kingdom, latitude $\sim 54°$N.

Collectively, the above-cited studies suggest that by $\sim 133{,}000$ to possibly $\sim 145{,}000$ yr ago the Fennoscandian and British ice sheets had apparently retreated and sufficient time had also elapsed for development of biologically active soils, a prerequisite for speleothem growth. If these ages are accurate (see below), they provide a minimum (i.e., youngest) age for the start of deglaciation in the vicinity of the caves from which the speleothems were obtained; that is, ice-sheet retreat had occurred prior to the time of *initiation* of speleothem growth.

Commencement of the penultimate deglaciation (i.e., the MIS 6/5 transition) in northwestern Europe before 135,000 yr B.P. is not easily reconciled with marine δ^{18}O ice-volume chronologies. Hence, the two pre-135,000 yr B.P. speleothem ages cited above deserve close scrutiny. A plausible objection to them is that they are based on AS uranium-series dating, a method with a precision inferior to that of TIMS uranium-series dating. However, it would be a mistake to dismiss these AS ages because: (a) speleothems are, in general, excellent substrates for uranium-series dating; (b) the accuracy of AS dating is comparable to that of TIMS for times younger than MIS 6, as shown by Hamelin *et al.* (1991) for corals marking the stand of the last interglacial sea level. (In this study, TIMS ages, given in their Table 1, were compared with AS ages, given in their text. In four of five comparisons, the AS ages were within 2000 years of the TIMS ages; in the remaining comparison, the AS age was 8000 years older than the TIMS age); and (c) the most recent TIMS uranium-series dating of last-interglacial sea levels (Henderson and Slowey, 2000; Henderson *et al.*, 2001; Gallup *et al.*, 2002) strongly support an early start of the penultimate deglaciation. Gallup *et al.* (2002), for example, demonstrated that sea level had attained 80% of its last interglacial high stand by 136,000 yr B.P. Should the AS dates cited above be replicated using the TIMS uranium-series dating methodology? Certainly.

In summary, speleothems from areas covered by or adjacent to ice sheets compose an important, but underutilized, source of information about the *initiation* of the penultimate and the last deglaciations. AS uranium-series ages of speleothems from northwestern Europe suggest that the penultimate deglaciation was underway by 133,000 years ago and possibly as early as 145,000, years ago, even at the latitude of the Arctic Circle. This inference can be checked by TIMS uranium-series dating of key speleothems studied, and hopefully archived, by previous workers. With the acquisition of TIMS ages for dozens of

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speleothems from northwestern European caves we might, perhaps a decade hence, be able to construct contour maps documenting the retreat of the British and Fennoscandian ice sheets during the last and penultimate deglaciations.

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