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HOW LONG AND HOW STABLE WAS THE LAST INTERGLACIAL?

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Abstract — Surface ocean indicators in the North Atlantic during marine isotope stage (MIS) 5 correlate closely with the vegetational succession in northeastern France. The Melisey I silty layer, which marks the end of the Last Interglacial biozone in La Grande Pile pollen record, appears coeval with the polar front advance C24 registered in the core V29-191 by a sharply increased presence of ice-rafted detritus and the cold water foraminifer *Neogloboquadrina pachyderma sinistral*. Since this event is younger than the peak of MIS 5d, the Last Interglacial, as recognized in northern France, correlates not only with the MIS 5e, but also with a substantial part of MIS 5d. The last interglacial in La Grande Pile was twice as long as the Holocene and the climate in its first half was apparently not less stable than during the current interglacial. If the future natural climates were to develop as analogs of the past, then the onset of the next glacial environments on land would be still many millennia ahead. © 1997 Elsevier Science Ltd.

INTRODUCTION

The last interglacial is commonly viewed as an interval of warm climate closely comparable in length with the elapsed part of the Holocene. Since the present interglacial is assumed to be a periodic analog of the last one, a major natural cooling is expected in the near future (Kukla *et al.*, 1972). We now question the validity of such an assumption, showing that the Last Interglacial, as defined in the terrestrial environments of western Europe, lasted about twice as long as the Holocene. If the current interglacial were indeed to follow the blueprint of the last one, we would be still many millennia away from the time when the climates in western Europe began to sharply deteriorate.

DATA

In the context of several reports of apparent severe cooling events during the last interglacial (Dansgaard *et al.*, 1993; Thouveny *et al.*, 1994; Cortijo *et al.*, 1994; Johnsen *et al.*, 1995; Lauritzen, 1995; Maslin and Tzedakis, 1996) we compared the paleoceanographic data on the marine isotope stage MIS 5 in the deep sea core V29-191, situated in eastern North Atlantic at 54°16′N and 16°47′W (McManus *et al.*, 1994, cf. location in Fig. 1) with the corresponding interval of lacustrine pollen-rich sequence at La Grande Pile (GP) in France (Woillard, 1975). The latter record covers the last 140 millennia, is essentially continuous and includes in its lower part sediments of the last interglacial labelled locally as Lure, but shown convincingly to correlate with the Eemian. Data from additional cores in both studied environments verify that the records are essentially continuous and represent regional conditions (McManus *et al.*, 1994; Beaulieu and Reille, 1992).

The ocean core has a fairly well differentiated oxygen isotope record, obtained from the benthic foraminifera *Cibicidoides*. It enables a reliable recognition of the boundaries of marine isotope stage 5. Following the convention (Emiliani, 1955), the MIS 5/4 is at the core depth of 650 cm, half way between the opposing isotopic peaks. The core does not penetrate deep enough to reach the peak of MIS 6, but the sharp shift of the isotopic ratio and the full glacial values of the left coiling *N. pachyderma* underneath identify the MIS 5/6 boundary at the 1070 cm depth with sufficient reliability (Fig. 2). The close correlation of the planktonic indicators with the core DSDP 609 demonstrates that the record is not interrupted by any hiatus (McManus *et al.*, 1994).

The ocean-surface conditions are represented in the core by the presence of ice-rafted detritus (IRD) and cold water planktonic foraminifer *Neogloboquadrina pachyderma sinistral*. The very low, almost negligible proportion of IRD and *N. pachyderma s.* indicate a relatively

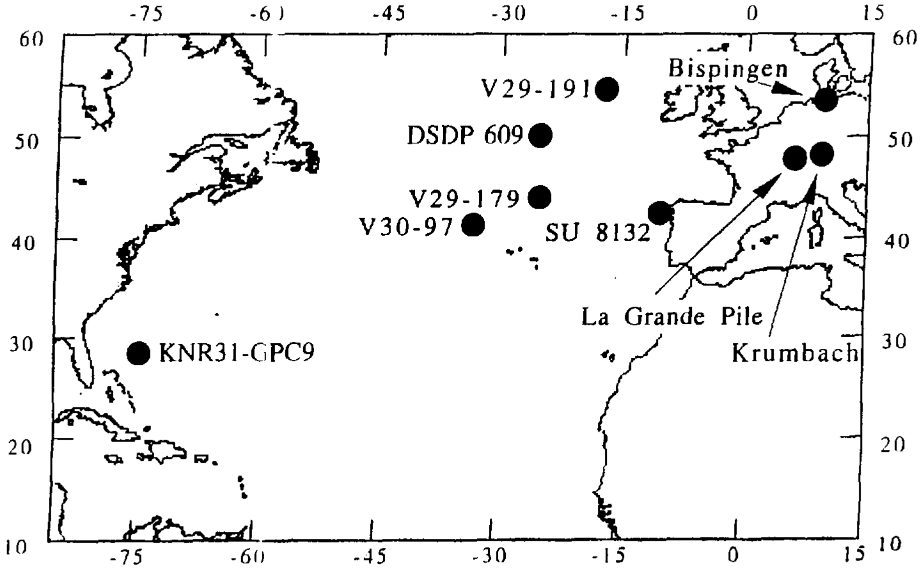

FIG. 1. Location of the sites mentioned in the text.

stable and warm ocean surface at the site in the lower part of MIS 5. At that time the penetrations of polar waters, if any, were infrequent, short-lived and marginal (Fig. 2). In the upper part of MIS 5, six polar water invasions are recorded by increased percentages of *N. pachyderma sinistral*. Four of them, labeled C19, C20, C21 and C24 are accompanied by a considerably increased deposition of ice-rafted detritus.

In the right part of Fig. 2, we plotted the classical well subdivided pollen record of the Last Interglacial and Early Glacial in La Grande Pile, France. The onset of the interglacial vegetation is recorded in the thinly laminated gyttjas in the core GP X at the depth of 1830 cm (Woillard, 1978). The replacement of the closed forest by the open steppe vegetation, the conventional upper boundary of the last interglacial (Menke and Tynni, 1984), is at the depth of 1570 cm. The top of the temperate interstadial St Germain II is at the depth of 1275 cm.

The GP cores X and XIV have been correlated with the SPECMAP chronology earlier (Molfino *et al.*, 1984). Based on the frequencies of selected taxa, Molfino, Heusser and Woillard placed the MIS 4/5 boundary at 1195 cm and the MIS 5/6 at 1830 cm of Woillard's composite record. The upper boundary is already well within the steppe vegetational zone of the so-called Lanterne stadial, a fact sometimes overlooked by other investigators (cf. Cortijo *et al.*, 1994).

The top of the Lure interglacial is at the depth of 1562 cm, at the lower boundary of the 10 cm thick Melisey I band of silty gyttja with aeolian admixture (Seret *et al.*, 1992) and steppe pollen assemblage 10). No indicators of particularly cold conditions were reported from this layer, which includes flora as well as beetles (Ponel, 1995).

The GP environment between the base of Lure and the top of Saint Germain II has been dominated by a closed forest, represented in the pollen count by around 90% tree pollen. During much of the Last Interglacial, the forest was a mixed deciduous one. From the Late Eemian until the end of St Germain II, the conifer pollen prevails, with only three zones in which the proportion of deciduous species reached significant values. The Last Interglacial climate in GP was relatively benign, but by no means uniform. Increase of *Taxus* in the early part of the interglacial at the core depth of 1770 cm (Guiot *et al.*, 1993) and the demise of hardwood elements at the depth of 1605 cm (Woillard, 1979) were interpreted as signs of significant cold spells.

The comparison of the La Grande Pile vegetational succession with the surface-ocean indicators in V29-191, aligned at the MIS 5 boundaries and made on the original depth scales (Fig. 2), reveals a close anticorrelation of the non-arboreal pollen (NAP) count with the variation of the left coiling *N. pachyderma*. The number of the anomalies, their depth spacing and the relative amplitude of the signals correlate reasonably well. The tree pollen minima have their counterparts in *N. pachyderma* spikes. There could be little doubt that the Melisey I steppe episode corresponds to the C24 polar water intrusion, the Montaigu event to C23 and the Melisey II to C21. Also, the tripartite temperate subzone with deciduous trees, St Germain I, appears to correspond to the warm ocean subzones W24, W23 and W22, while St Germain II correlates with W21. All these warm ocean intervals are marked by low percentages of the left coiling *N. pachyderma*.

It also appears that the oscillatory increase of conifers at the expense of deciduous trees in the second half of the Last Interglacial in GP has a parallel in a noticeable, although still limited, increase in the percentage of the left coiling *N. pachyderma*. Little thickness and sharp boundaries of the steppe interlayers Melisey I and Melisey II correspond well with the equally small relative thickness and abrupt boundaries of their marine counterparts. The only exception to the otherwise close correlation is in the upper part of the GP record with the Ognon interstadials. In this interval the relatively open vegetation at GP correlates with the warm ocean surface of the basal W20 zone (Fig. 2).

RELATION WITH THE OXYGEN ISOTOPE STRATIGRAPHY

The oldest polar water incursion, the C24, is considerably younger than the MIS 5d heavy oxygen isotope (cold) peak (Fig. 2). During a substantial part of the MIS 5d, a substage usually interpreted as marking the first episode of the Early Glacial ice build-up, the surface waters in the central segment of North Atlantic were still relatively warm. It follows from our data that the chronostratigraphic position of the Last Interglacial, as recognized in French pollen records, disagrees with the timing of MIS 5e, its presumed marine equivalent.

The disagreement has serious stratigraphic implications. It has been commonly assumed that the first Weichselian interstadial on land corresponds to the MIS 5d subzone and that the glacial onset is coeval with the MIS 5e/5d boundary (cf. Mangerud *et al.*, 1979 or Dansgaard and Duplessy, 1981 and many others). In GP this is clearly not so. The demise of the interglacial woodland is substantially younger than the heavy isotope peak of MIS 5d. Unless the placing of the isotope peak in V29-191 were in serious error, the interglacial at GP would be considerably longer than the MIS 5e.

To find out whether the MIS 5d peak in V29-191 is correctly identified, we compared its stratigraphic position with some other benthic oxygen isotope records from the North Atlantic, aligned at the MIS 4/5 and MIS 5/6 boundaries. We assumed that the sedimentation rates within MIS 5 were nearly constant and plotted the isotope values as a function of depth (Fig. 3). We found the MIS 5d peak in V29-191 at approximately the same relative depth within MIS 5 as in the cores V30-97, V29-179 (Mix and Fairbanks, 1985; Streeter and Shackleton, 1979) and

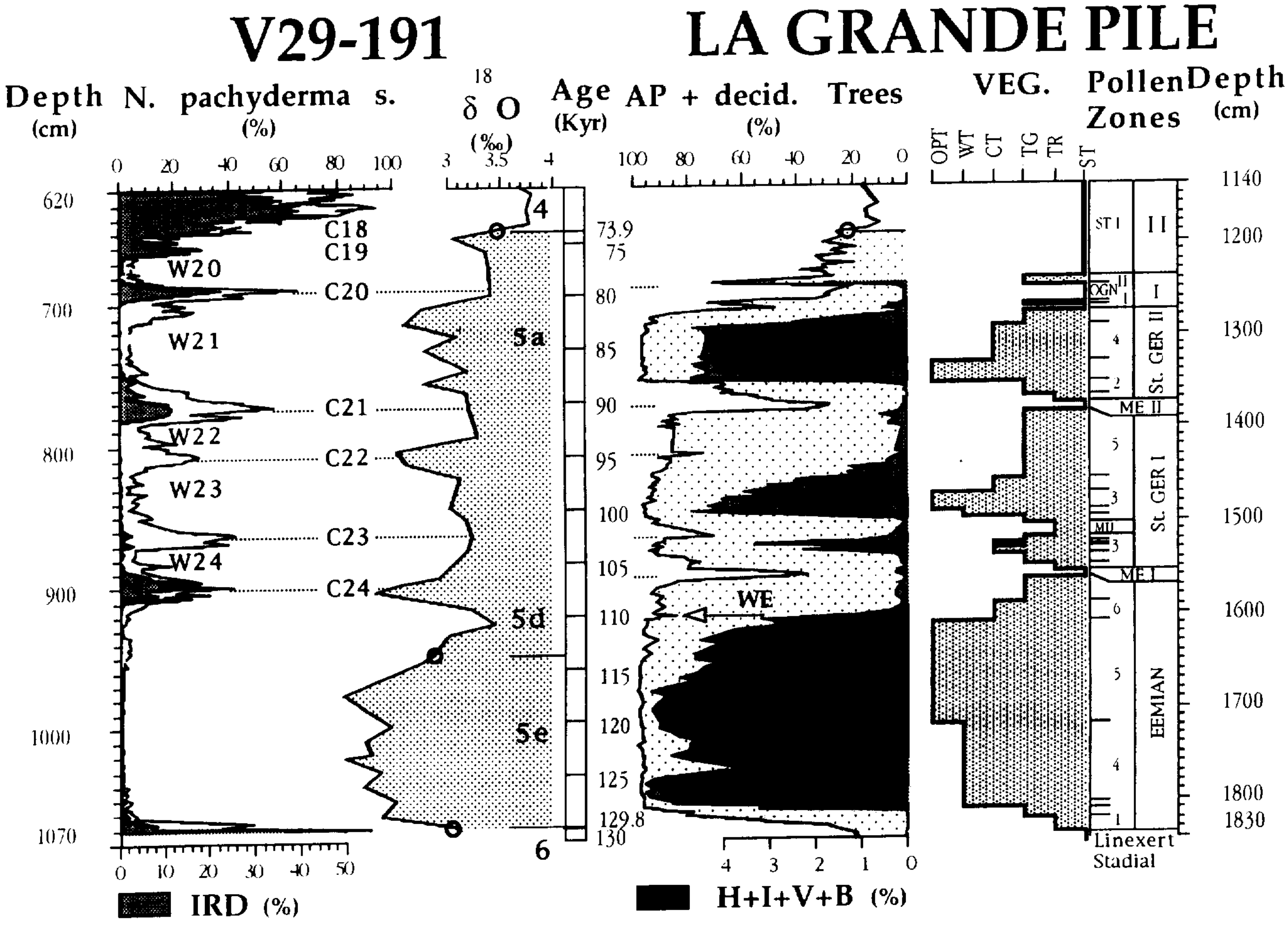

FIG. 2. Comparison of the paleoceanographic record of MIS 5 sediments in the deep sea core V29-191 (McManus *et al.*, 1994) with the vegetation zones in the La Grande Pile boreholes GP X and XIV (Woillard, 1975, 1978). Both records are compared on their original depth scales and aligned at MIS 4/5 and MIS 5/6 boundaries, marked by open circles. Percentage of the left coiling *Neogloboquadrina pachyderma* shown in full line. W20 to 24, and C18 to 24 are the warm and cold sea-surface episodes, respectively (McManus *et al.*, 1994). Percentage of ice-rafted detritus (IRD) is shaded. Age obtained by linear interpolation of thickness between MIS 4/5 and 5/6. La Grande Pile pollen record from unpublished original Woillard's counts and from her interpretation in Woillard (1978). Non-arboreal pollen blank, coniferous trees lightly dotted, deciduous trees heavy dotted and climate indicator taxa *Hedera, Ilex, Viscum* and *Buxus* in full (corresponding percentage scale at bottom). WE with open arrow marks the 'Woillard's event'. VEGetation zones are STeppe, TReeless shrubland, TaiGa, Cold Temperate forest, Warm Temperate forest and forest of climatic OPTimum. Pollen zones after Woillard (1978). ME I is Melisey I, MU is Montaigu event and OGN are Ognon interstadials. The I and II in the right column stand for Lanterne stadials I and II. The GP sequence has been restudied in additional cores from the same basin by de Beaulieu and Reille and the principal features of the pollen sequence were confirmed. Their cores have not been used here, because they were sampled in a dry state after several years of storage, with potentially distorted depth information.

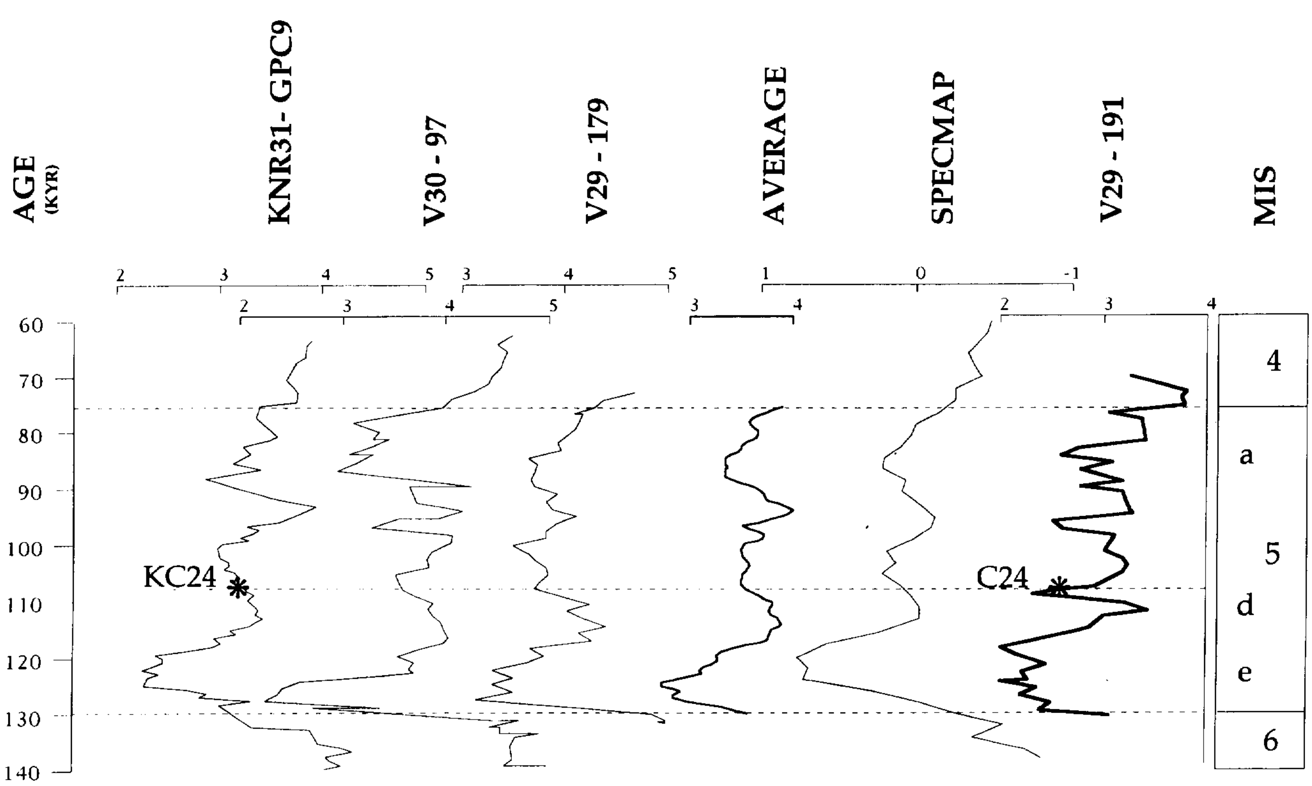

FIG. 3. Benthic oxygen isotope records of the MIS 5 in North Atlantic cores V29-179, V30-97 (Mix and Fairbanks, 1985; Streeter and Shackleton, 1979) and KNR 31-GPC9 (Keigwin *et al.*, 1994), as well as their arithmetic average. A tentative time-scale is obtained by linear interpolation of depth between MIS 4/5 and MIS 5/6 boundaries dated after Martinson *et al.* (1987). Compared with the V29-191 record (in full) and with the SPECMAP chronology. Also shown are the levels of the cold KC 24 and C24 events. MIS: marine isotope stages and substages. Upper horizontal bars show oxygen isotope ratios.

KNR31-GPC9 (Keigwin *et al.*, 1994). If anything, the peak in V29-191 could be somehow younger, but not older than in the SPECMAP chronology (Martinson *et al.*, 1987). The apparent age would be expected to be older, not younger, if the sedimentation rates in the cold substages locally increased.

It may be noted that with few exceptions, such as V29-197, the oxygen isotope records of the substages MIS 5a to 5c do not correspond exactly with the SPECMAP global average model. This holds for both benthic as well as planktonic data (Labeyrie *et al.*, 1995). Whether this is a sampling problem or whether it has something to do with the deep-water response to the ice surges into this part of the world ocean (Paillard and Labeyrie, 1994) is not yet clear. (The second mechanism could explain why in V29-191 the C24 anomaly is accompanied by a decrease, not an increase of the benthic oxygen isotope ratio.)

In practice, the upper and lower boundaries of isotope stages in deep-sea cores as identified in the core data do not necessarily represent precise time lines. Their placing depends on sampling intervals, regional conditions of the site, strength of the signal, etc. To double-check the proposed correlation of MIS 5d with the GP sequence, we aligned the GP data with the *N. pachyderma s.* record of V29-191 by setting the Melisey I coeval with the C24 and Lanterne I with C20 (Fig. 4). We then extrapolated the position of the MIS 4/5 and MIS 5/6 boundaries, assuming a constant sedimentation rate throughout stage 5. The correlation coefficient of the two records so aligned is 0.83. We added to the diagram the carbonate record of KNR31-GPC9, assuming that the pronounced carbonate low at the depth of 2020 cm (Keigwin *et al.*, 1994), some 20 cm above the MIS 5d isotopic peak (Fig. 3), might be coeval with the C24 polar front advance in V29-191. We labeled the carbonate low at the depth of 1835 cm as KC 20 and linked it with C20. Extrapolated relative depth of MIS 4/5 agrees very well in all three records. The MIS 5/6 boundary position in V29-191 and in GP also agrees reasonably well.

Our results are further supported by the pollen directly recovered in the deep-sea core SU 8132 off the Iberian coast (Turon, 1984). While the oxygen isotope record of MIS 5 in this core is expressed too poorly to identify the MIS 5d peak clearly, the relative depth of the zone with deciduous pollen corresponds closely with our comparison of V29-191 with GP. Unless the sedimentation rates varied widely, the interval with interglacial pollen in SU 8132 would be considerably longer than the thirteen or so millennia assigned to the MIS 5e.

We thus conclude from the performed tests that the identity of MIS 5d in V29-191 and its correlation with the La Grande Pile record is sufficiently well established. Consequently, our findings show that:

(1) The Lure (Last Interglacial) segment of La Grande Pile pollen record is not a terrestrial equivalent of MIS 5e only, but correlates also with a substantial part of MIS 5d, including its isotopically heaviest peak.

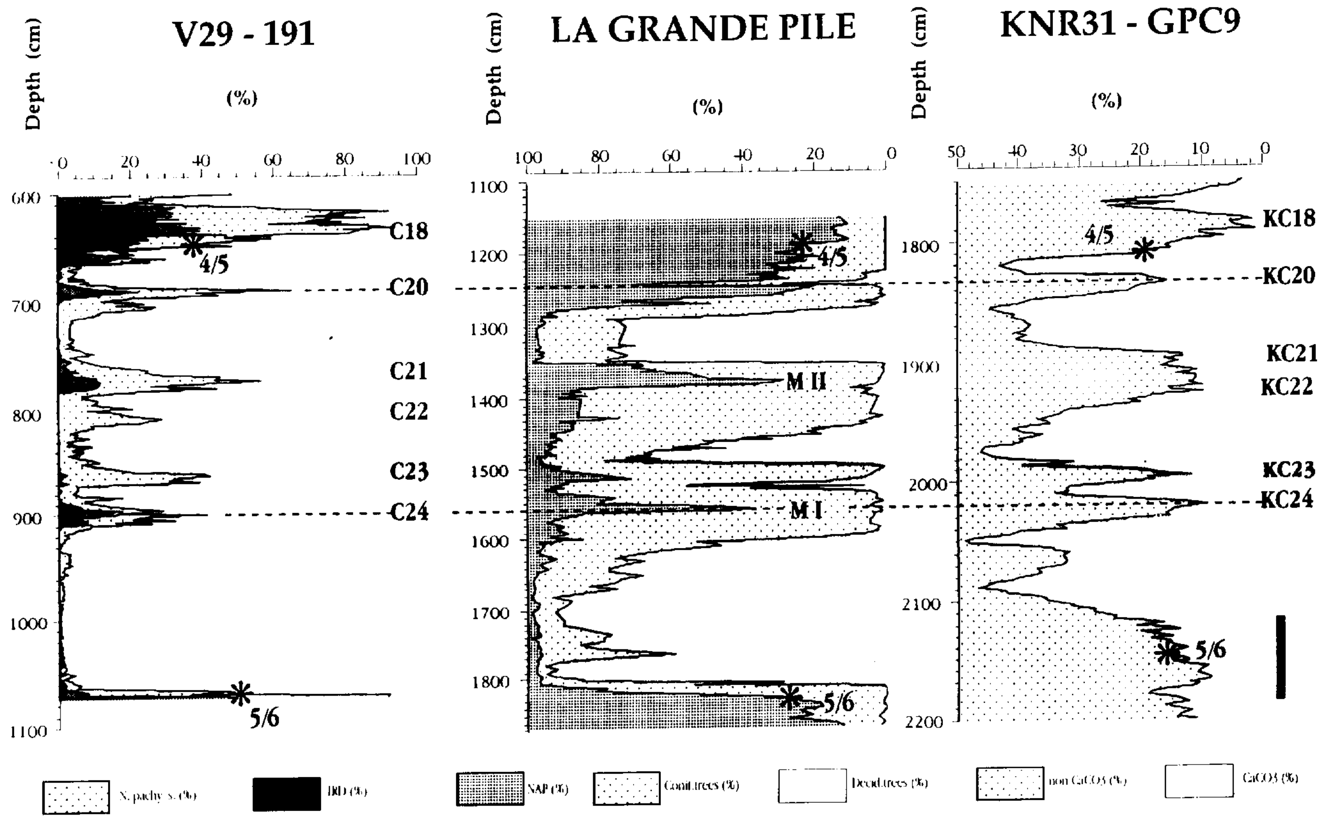

FIG. 4. Comparison of the IRD and *N. pachyderma s.* records in V29-191 (McManus *et al.*, 1994) with the percentage of tree pollen at La Grande Pile (Woillard, 1978) and the proportion of carbonate by weight in KNR31-GPC9 (Keigwin *et al.*, 1994). Plotted in the original depth scales and aligned at the C20-KC 20 and C24-KC 24 levels. The position of the MIS 4/5 and MIS 5/6 boundaries in La Grande Pile and in both deep-sea cores is extrapolated by extending the average sedimentation rates from the C24–C20 segment. Vertical bar shows the interval of the gradual oxygen isotope drop at termination II in the Knorr (KNR) core. Note that the shading is different from Fig. 2.

(2) The vegetation changes at La Grande Pile were synchronous with the surface ocean variations in the central part of the North Atlantic, but were delayed behind the benthic oxygen isotope change.

(3) The conventional glacial-interglacial boundary as identified in the oxygen isotope variations of benthic fauna does not correspond to the glacial and interglacial boundary of La Grande Pile floral sequence. The MIS 5e/5d boundary is older than the Eemian/Weichselian boundary.

DURATION OF THE LAST INTERGLACIAL

The close correlation of the records from vastly different sedimentary environments implies that the sedimentation rates within the MIS 5 zone at both studied sites were sufficiently uniform to justify a tentative chronology based on relative thickness. Additional observations support this conclusion. The mean sedimentation rate of MIS 5 in the deep sea core V29-191 is only 15% lower than over the first 74 ka and is practically the same as within MIS 5e. Similarly, the mean sedimentation rate in the radiocarbon dated lacustrine segment above MIS 4/5 boundary in GP differs by only 4% from that of the older segment. A near uniform deposition rate in GP is also shown by the data of Woillard and Mook (1982). If the sedimentation rates differed so little during the pleniglacial and early glacial, with strikingly different climatic regimes, it is highly unlikely that they would have significantly varied within the much more uniform interglacial and early glacial environments. The only possible exceptions are the lithologically distinct Melisey interlayers, which are each about 10 cm thick. These sharply delimited bands of organic detritus with the admixture of eolian dust should have a higher, rather than lower sedimentation rate than the surrounding gyttja. In no way could they represent a several millennia long substage MIS 5d (Beaulieu and Reille, 1992) as proposed by some researchers (cf. e.g. Guiot *et al.*, 1989).

Following Martinson's model (Martinson *et al.*, 1987), we assigned the age of 73.9 ka to the MIS 4/5 boundary and 129.8 ka to the MIS 5/6 boundary. Assuming uniform sedimentation rates, we then added an approximate time scale to the data of Figs 2 and 3. Apparent ages of the key horizons in the four deep-sea cores shown in the figures compare reasonably well with the SPECMAP chronology. The intermediate warm peak W23 in V29-191 and the midpoint of the St Germain I interstadial occur at about 98 ka, reasonably close to the 99 ka of the warm SPECMAP MIS 5.3 (which in the stacked deep-sea chronology represents the climax of substage 5c). Most importantly, the 110.7-ka-old SPECMAP MIS 5d peak corresponds closely with the 111 ka age of the corresponding V29-191 level.

The *N. pachyderma s.* subzone C24, which marks the invasion of polar waters into mid-Atlantic and probably also the change of the bottom water properties at the KC 24 level in KNR31-GPC9, appears to correlate with the base of the eolian silt Melisey I in La Grande Pile. The latter marks the interglacial end in GP, and is about 107 thousand years old. Thus, the Last Interglacial, as recognized in its Lure equivalent in France, is some 23 millennia long, twice the estimated duration of Bispingen diatomites in Germany (Müller, 1974).

This is not the first time that the Lure interglacial has been claimed to be substantially longer than ten millennia. Guiot and co-workers estimated the duration of the Eemian in Grande Pile at first (Guiot *et al.*, 1989) to 18 and later (Guiot *et al.*, 1993) to 16 thousand years. In both cases, they took into account the results of Turon's study (Turon, 1984).

THE LAST INTERGLACIAL IN GRAND PILE AND THE EEMIAN

The Eemian was originally named after the marine clays with temperate Lusitanian fauna in the Netherlands (Harting, 1874, 1875). Its palynological zonation was defined in detailed studies at the localities in Denmark and northwestern Germany (cf. Jessens and Milthers, 1928, or Selle, 1962). The type area of the palynostratigraphically defined Eemian is there, not in La Grande Pile.

The vegetational sequence of Lure at La Grande Pile is a typical Eemian succession. There could be little doubt that Lure and the Eemian elsewhere in Europe represent the same biostratigraphic unit. However, the question arises whether they also belong to the same chronostratigraphic unit, that means whether they are of the same duration. The Eemian vegetational sequence follows a fairly similar pattern all over Europe. Most palynologists therefore consider the onset of glacial open vegetation in western Europe to be by and large synchronous (Menke and Tynni, 1984). However, judging from the diachronous oscillations of vegetational belts in the more recent past (Zagwijn, 1994), this is by no means guaranteed. It is indeed possible that the coniferous woodlands in the type area of the Eemian in Jutland were replaced by open vegetation earlier than in the Vosges.

On the other hand, it is difficult to visualize a several thousand year-long interval during which the lush deciduous forests at La Grande Pile would have coexisted with harsh steppes and tundras in northern Germany and Denmark, some 600 km away. Such would have been the case if the frequently cited estimate of the 11 millennia long Eemian interglacial in Bispingen, Germany, were correct. Here, Müller (1974) estimated the duration of the Last Interglacial in pollen-rich diatomites which are in part annually laminated. His estimate might be indeed in error. He was able to count only 1900 annual laminations through the early part of the Eemian diatomites, which have up to five times higher content of carbonate than the rest of the deposit. The sedimentation rates through the remainder of the interglacial diatomites were estimated from the ratio of silica to organic matter, apparently without the allowance for carbonate. Elsewhere in Europe, using a different approach, Dabrowski (1971) calculated the length of Eemian to 18 thousand years. He measured the concentration of pollen grains per volume of sediment in Glywczyn, Poland, and calibrated the values in recent lakes. (At this point, we want to stress that we are not questioning the correlation of the lower boundary of Eemian with the SPECMAP date of Termination II as was earlier done by Jouzel *et al.* (1987) for Vostok or by Winograd *et al.* (1992) for Devils Hole in Nevada.)

CLIMATE OF THE SECOND HALF OF THE LAST INTERGLACIAL

The climatic scenario of the second half of the interglacial emerging from our data differs considerably from conventional models which assume a by-and-large parallel change of vegetational cover with the ice build-up, both directly responding to orbital forcing. Our data point to a different scenario. The expansion of the frost-sensitive evergreen shrubs in the climax of the Last Interglacial in GP, accompanied by oscillatory replacement of hardwood elements by conifers, occurred at a time when relatively warm waters were present in the central North Atlantic (cf. Ruddiman *et al.*, 1980), but when the ice had already started growing in the high latitudes, as indicated by the change of isotopic composition of bottom waters. According to our approximate time-scale, this interval lasted from about 117 to about 111 ka BP.

How rapid and intensive the ice increase was is unclear. This is because the change of the isotopic composition of benthic foraminifera, most frequently interpreted in terms of ice volume, may also involve a significant change of the bottom-water temperature, particularly at the 5e/5d boundary (Shackleton, 1981). The Knorr core data of Keigwin *et al.* (1994) suggest that the northern-source deep water in MIS 5d, that is in the second half of the Eemian, might have been produced in an intermittent fashion.

The interglacial vegetation of western Europe at that time was gradually adjusting to cooler summers accompanied by warmer winters and wetter climate, which still at that time must have been considerably more maritime than today (Zagwijn, 1994). It sounds somehow surprising that the first half of MIS 5d might have been contemporaneous with the climatic optimum, but this in GP indeed seems to be the case (cf. Fig. 2). The optimum was defined by Iversen (1944) by the presence of the so-called 'indicator species' *Ilex*, *Hedera* and *Vitis*. These evergreen shrubs do not tolerate deep subfreezing temperatures. Their maximum was attained in the second half of the GP interglacial. Climate reconstructions based on these evergreens are considered by most palynologists to be more reliable than those based on transfer functions (Aaby and Tauber, 1995; Zagwijn, 1994).

Dka represent an oscillatory climate shift which might have been more pronounced and less benign in northern

Europe than at La Grande Pile. It is even possible that the ocean circulation and sea-level changes in the northernmost North Atlantic during the Late Eemian significantly affected the Greenland ice and the deep-water chemistry without leaving obvious traces in the vegetation of western and central Europe. The meridional temperature gradient might have increased considerably at that time, both in the ocean as well as on land.

A major climate shift occurred at about 111 ka, some 19 thousand years after the onset of the interglacial. Then the conditions at GP deteriorated drastically. The deciduous trees of the *Picea–Abies–Carpinus* forest were all but eliminated within a few centuries and replaced by the boreal taiga. The taiga of the so-called katathermal phase of the interglacial lasted in GP for another four millennia. Woillard estimated that in GP this abrupt shift took about 150 ± 75 years, assuming the 11-ka duration of the interglacial. However since the Lure in GP is twice as long as she thought, the estimate has to be revised to approximately 300 ± 150 years.

Woillard and Frenzel (1991) and Frenzel and Bludau (1987), analyzed an apparently identical abrupt vegetation shift in the annually banded sediments at Krumbach, Germany. There the 'Woillard event' is so sharp that Frenzel and Bludau considered it to be a hiatus. The event is preceded by at least 1500 years of a gradual decline of mixed forest and followed by at least 1650 years of the late Eemian coniferous woodland. It may also be at this time when the sea-level apparently dropped in the North Sea by several meters, as indicated at Fjosanger (Mangerud *et al.*, 1979), and Apholm (Seidenkrantz and Knudsen, 1994). It has been proposed based on the GP pollen record, that the katathermal phase of the Last Interglacial proceeded in two waves of rapid climate deterioration followed by gradual relaxation (Beaulieu and Reille, 1992). The end of the GP Eemian arrived at 107 ka and was probably equally as rapid as the earlier Woillard event. A scenario which would best fit our data involves a gradual ice build-up in the high latitudes in the second half of the Eemian accompanied by the eastward deflection of the North Atlantic warm water gyre and punctuated by periodic massive ice discharges (Bond and Lotti, 1995; Broecker, 1994). Ocean circulation, both the deep and the surface one, as well as changes in fresh water influx and sea-level were apparently instrumental in bringing the interglacial/glacial shift to the middle latitudes of western Europe.

EEMIAN VERSUS HOLOCENE CLIMATES

The trend toward cooler summers and wetter and milder winters started some 13 thousand years after the onset of the Last Interglacial. This is the time which approximately corresponds to the current chronological position within the periodic glacial/interglacial cycle. Obviously then, the notion of the unstable Eemian climates, opposed by supposedly stable Holocene (Dansgaard *et al.*, 1993) has to be carefully reconsidered, since only the first half of the Eemian may be justly compared with the present interglacial. In agreement with Zagwijn (1994), we see no reason to conclude that the climate of the elapsed part of the Holocene was any more stable than the corresponding part of the Last Interglacial.

The dramatic winter cooling reported by Field *et al.* (1994) within the *Carpinus* zone in Bispingen would have occurred in the second half of the interglacial, not in the first part which corresponds to the Holocene. The reality of Field's reconstruction based on transfer functions is doubtful and has been seriously questioned (Aaby and Tauber, 1995; Zagwijn, 1994). However even if valid, it would not support the notion of a purported contrast of Eemian with supposedly more benign Holocene climates, because it would have happened in the second, not in the first half of the interglacial. The same comment holds for the inter-Eemian spell reported by Thouveny and coworkers (Thouveny *et al.*, 1994) in southern France or by the ocean anomaly dated at about 122 ka by Maslin and Tzedakis (1996). All age estimates which are based on the assumption of the MIS 5e being equal in length to the supposedly 11 millennia long Eemian need to be revised.

The disagreement between the biostratigraphic units defining the Last Interglacial on land, their supposed isotopic equivalents in the ocean and the conventional idealized climatostratigraphic concept is serious. It must be taken in account if the mechanism of gross climate changes is ever to be understood.

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