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Last glacial European Ice Sheet variability – cause and effect illustrated by upper ocean temperature and salinity records.

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We present high resolution, multi-proxy palaeoceanographic records from core MD01-2461, Porcupine Seabight (51º 45'N, 12º 55'W, 1153m water depth) which detail the relationship between upper ocean and intermediate water conditions and European ice sheet variability during the last glacial.

Ice rafted debris (IRD) flux and provenance tools record episodes of ice rafting from the circum-North Atlantic ice sheets during the last 45kyrs. Within this time periodic collapses of the Laurentide Ice Sheet are clearly recorded at the core site (H1-H4) by the presence of Hudson Bay-sourced dolomitic carbonate, and a variable combination of high magnetic susceptibility, εNd $<$ -24, and Churchill Province-sourced hornblende grains (^{40}Ar/^{39}Ar 1650-1900 Ma). Distinctive British and Icelandic ice sheet sourced IRD, however, record millennial-scale variability of these European ice sheets (EIS), with greater fluxes of British ice sheet debris towards the LGM documenting ice sheet growth.

High resolution Mg/Ca analyses of *G. bulloides* (Gb) and *N. pachyderma* (sin., Nps) provide quantitative sea surface (SST) and thermocline (Nps depth range) temperature records. Paired with oxygen isotopes they allow δ^{18}O surface water ($\delta^{18}O_{sw}$) and salinity to be derived. Ice rafting from the EIS occurred following both warm and

cold pulses in SST. Surging during cold surface conditions occurred with a 2-4 kyr frequency, while precursory IRD events apparently responded to SST warming of 2-4ºC. Freshening of surface waters associated with these European ice rafting events is recorded by lightening of up to $3‰$ in$g\delta^{18}O_{sw}$, while $\Delta\delta^{18}O$ (Gb-Nps) and ΔT (surface and thermocline depth) suggest strong thermal and salinity gradients developed during these phases. An anti-phase relationship between thermocline temperature and $g\delta^{18}O_{sw}$ further suggests that surface freshening caused the thermocline to shoal following EIS discharge. These episodes of well developed upper ocean stratification appear to have reduced ventilation of intermediate waters, as represented by coeval benthic$g\delta^{13}C$ decreases.