Tracking the provenance of Greenland-sourced, Holocene aged, individual sand-sized ice-rafted debris using the Pb isotope compositions of feldspars and $^{40}Ar/^{39}Ar$ ages of hornblendes: Earth and Planetary Science Letters.

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Supplementary Information

This document contains text that details the specifics of our laser ablation MC-ICP-MS method and construction of the Gaussian curves used to present our Ar-Ar geochronological data. Also included are Figures S1, which presents $^{206}Pb/^{204}Pb$ versus $^{208}Pb/^{204}Pb$ isotope plots for Greenland ice-rafted debris sources presented in this study, and Figure S2, which compares these data to the $^{208}Pb/^{204}Pb$ ratios observed in offshore marine sinks. All raw data is presented in Tables S1, S2 and S3, which detail the Pb-Pb isotope ratios of Greenland sources (S1) and marine sinks (S2), in addition to all Ar-Ar data collected from both terrestrial and marine samples (S3).

Laser ablation MC-ICP-MS

All ablation was performed in a 100% He environment using a 150 µm diameter spot, a repetition rate of 10 Hz and a power density of ~5.5 J cm^{-2}. Helium and the ablated material were mixed with Ar (+ N_2) gas down stream of the ablation cell in a glass mixing-bulb. Typical gas flow rates were 1 l min^{-1} He, 1 l min^{-1} Ar and 60 ml min^{-1} N_2. Each analysis consisted of a 60 second gas blank (that constituted an on peak zero), a short period of pre-analysis when surface contamination was removed, followed by 120 seconds of data collection after the signal had grown in. All Pb isotopes and ^{200}Hg were measured simultaneously in faraday collectors with 10^{11} Ω resistors.

Total Pb intensity during analyses was typically between ~0.4-1.2 V (average ~0.7 V). Isobaric interference of ^{204}Hg on ^{204}Pb were initially corrected using "on peak zeros" collected with the laser off during the gas blank. Any ^{200}Hg detected during the analysis (laser on) was used to further correct for isobaric interference of ^{204}Hg on ^{204}Pb using the natural $^{204}Hg/^{200}Hg$ ratio (0.2973; Platzner, 1997). The ^{204}Hg intensity was typically small (<0.5 mV) and only ~0.5 % of the measured ^{204}Pb. Comparing the average signal strengths from the analysis of the standards with the analysis of the feldspars allows for an estimation of the concentration of Pb in the feldspars (Tyrell et al.,

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2006). On this basis, the average concentration is estimated to be ~50 ppm. Instrumental mass bias was corrected for by bracketing groups of six analyses with analyses (n = 171) of National Institutes and Standards (NIST) 610 glass (~400 ppm Pb) using the double spike Pb isotope ratios of Baker et al. (2004). NIST 610 was analysed (n = 171) with a 100-µm diameter spot and a repetition rate of 4 Hz with similar power density as our unknown feldspars. Concurrent analysis of NIST 612 (~40 ppm Pb) with a 150 µm spot and 10 Hz repetition rate were made throughout the duration of our study. These results indicate that our measurements are both sufficiently accurate and precise, yielding the following values and uncertainties to 2 sd (relative to the values of Baker et al., 2004 as shown in parentheses): $^{206}Pb/^{204}Pb$ = 17.092 ± 0.024 (17.099 ± 0.003), $^{207}Pb/^{204}Pb$ = 15.509 ± 0.026 (15.516 ± 0.002), $^{208}Pb/^{204}Pb$ = 36.998 ± 0.08 (37.020 ± 0.007), $^{207}Pb/^{206}Pb$ = 0.90734 ± 0.00024 (0.90745 ± 0.00004), $^{208}Pb/^{206}Pb$ = 2.1646 ± 0.008 (2.1651 ± 0.0001). We take the 2 sd reproducibility of NIST 612 over all the analytical sessions to reflect our external precision at the 95% confidence level. To quantify measurement reproducibility for our feldspar analyses we either used the larger of the external precision given by NIST 612 or the internal measurement uncertainty at 2 standard errors (2SE).

Ar-Ar Gaussian Curves (Probability Distribution Functions)

Gaussian curves for argon – argon geochronological data were constructed using typical methods (i.e. Adams and Kelly, 1998) applying the equation;

$$f(x) = a \exp\left(-\frac{(x-b)^2}{2c^2}\right)$$

Where *a* (the height of the curve) is defined by the relative frequency of grains reporting a certain age, *b* (the position of the curves peak) is defined by the calculated Ar-Ar age, and *c* (the width of the curve) is defined by the standard deviation of the analyses (2sd). Presented Ar-Ar data (Figs. 4 and 7) represents probability distribution functions (PDF's) constructed by summing these Gaussian curves. Hence, reproducible data with low individual errors produce a tall, sharp Gaussian peak, while more erroneous data sum into a low, oblique curve.

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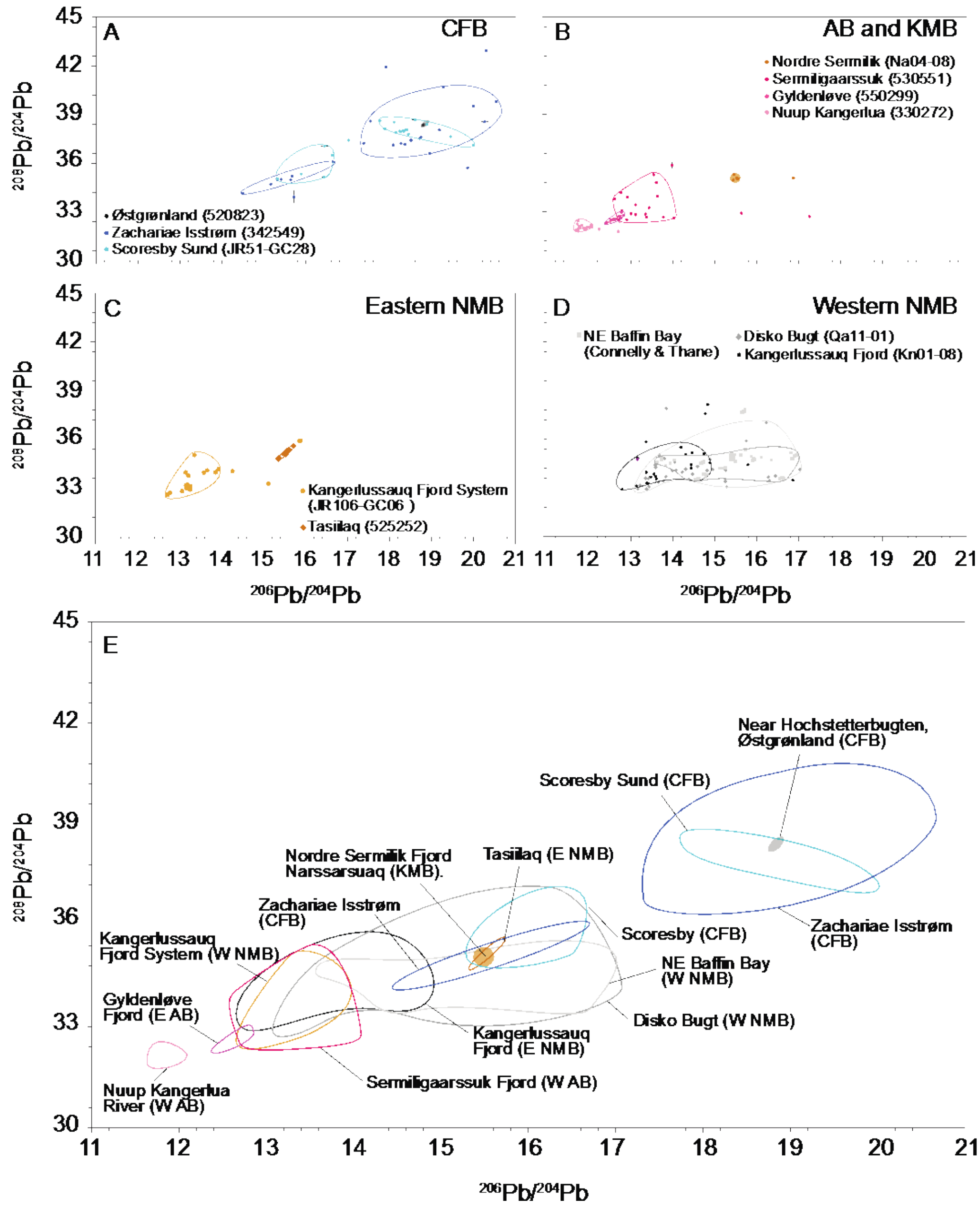

Figure S1. The Pb-isotope composition ($^{206}Pb/^{204}Pb$ vs. $^{208}Pb/^{204}Pb$) of individual sand-sized (>150μm) feldspars in Greenland glacifluvial and fjord sediments from localities along the coastlines of the Caledonian Fold Belt (CFB) (**A**), the Archaean Basement (AB), and Ketilidian Mobile Belt (KMB) (**B**), and the eastern (**C**) and western **(D**) Nagssugtoqudian Mobile Belt (NMB). A summary cross-plot is also presented (**E**) for the range of Pb isotope values for each sample studied. See map in Figure 1 (and Tab. 1) for sample locations. Grey data (Northern domain) in (G) from Connelly and Thrane (2005) determined from replicate analysis of individual feldspars in bedrock specimens from the region north of the proposed collisional suture for the Nagssugtoqidian-Rinkian orogen within central Disko Bugt. Data >21 $^{206}Pb/^{204}Pb$ from Zachariae Isstrøm (n = 2) not shown.

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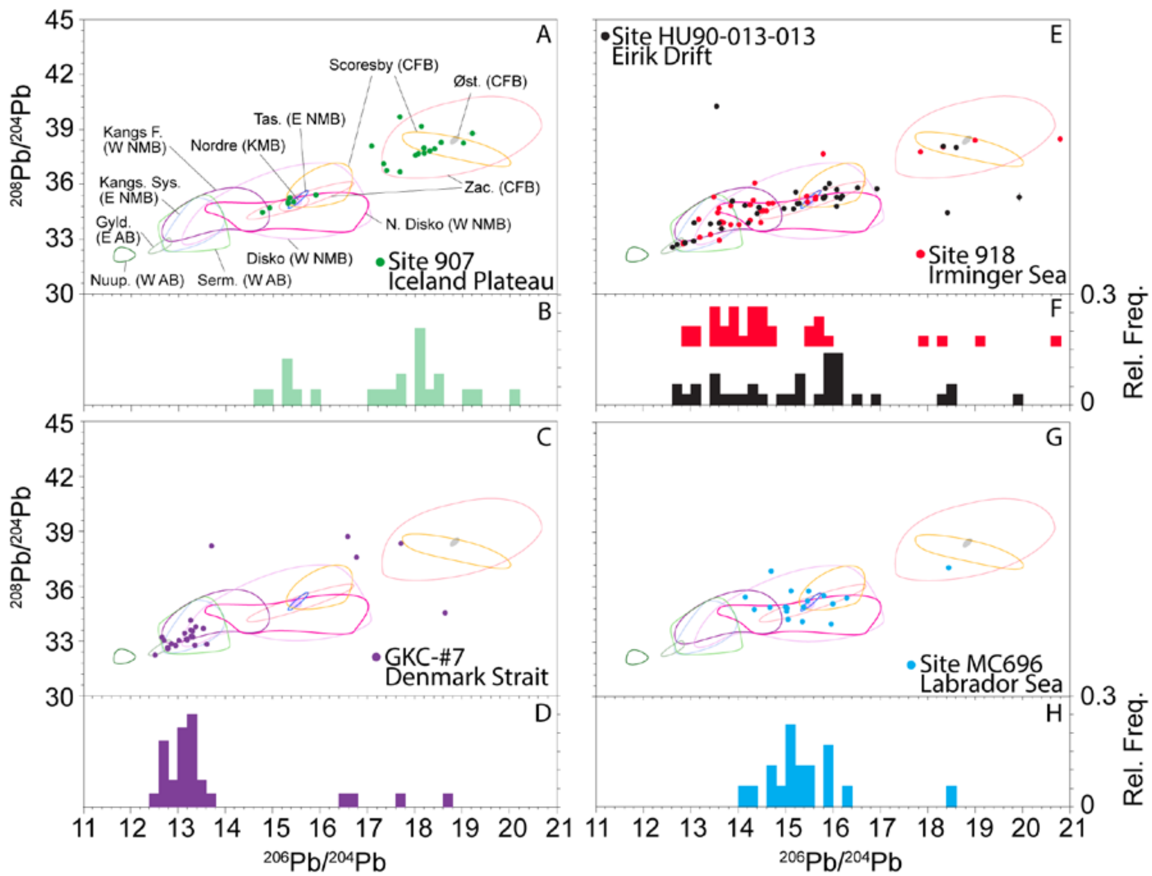

Figure S2. Pb-isotope composition of individual sand-sized (>150µm) feldspars from Greenland-proximal marine sediments deposited during the Holocene, highlighting spatial variation in $^{206}Pb/^{204}Pb$ vs. $^{208}Pb/^{204}Pb$. Crosses centered on individual data represent their respective 2σ uncertainties in Pb–Pb space. Where no cross is evident, uncertainties are smaller than the width of symbol used. Feldspars measured from ODP Sites 907 (**A**) and 918 (**E**) were deposited, respectively, during the Early Holocene (~10 ka) and Middle Holocene (~6 ka) (see Tab. 1). Feldspars measured from Sites GKC#7 (**C**), MC696 (**G**) and HU90-013-013 (**E**) deposited during the modern or latest Holocene (see Tab. 1). See Fig. S1 for data used to define 'source bubbles' shown in all panels. Øst. = Østgrønland, Zac. = Zachariae Isstrøm, Scoresby = Scoresby Sund Fan, Disko = Disko Bugt, Tas. = Tasiilaq, Serm = Sermiligaarssuk Fjord, Gyld. = Gyldenløve Fjord, Nuup = Nuup Kangerlua River, Kang Sys. = Kangerlussauq Fjord System, Kang. F = Kangerlussauq Fjord, Norde. = Nordre Sermilik Fjord Narssarsuaq, KMB = Ketilidian Mobile Belt, E/W AB = East/West Archaean Block, E/W NMB = East/West Nagssugtoqidian Mobile Belt, CFB = Caledonian Fold Belt. Data >21 $^{206}Pb/^{204}Pb$ from Sites 918 (n = 3) and 907 (n = 1), indicative of CFB sources, not shown.

Reference not cited in main text

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