SUPPLEMENTARY INFORMATION

S1: New bulk collagen stable isotope results and quality controls for the individuals from Rattar and Quanterness analyzed at SFU

SSFU	Site	Species	Element		$\delta^{13}C_{VPDB}$	$\delta^{15}N_{AIR}$	$\delta^{34}S_{VCDT}$	wt%C	wt%N	%S	$C:N_{atomic}$	$C:S_{atomic}$
2586	Rattar, Caithness	Human	Teeth	M2	-20.6	12.0	13.6	44.0	16.0	0.2	3.2	527.9
2587	Rattar, Caithness	Human	Teeth	M2	-21.1	10.2	15.8	43.9	16.4	0.2	3.1	574.5
2588	Quanterness	Human	Teeth	M (ND)	-20.1	11.5	15.6	44.3	16.2	0.2	3.2	568.5
2590	Quanterness	Human	Teeth	M (ND)	-20.9	11.0	15.6	43.3	15.8	0.2	3.2	544.2
2591	Quanterness	Human	Teeth	M (ND)	-20.7	13.0	16.1	43.1	15.9	0.2	3.2	578.7
2592	Quanterness	Human	Teeth	M (ND)	-21.4	9.8	15.2	42.7	15.0	0.2	3.3	488.3
2593	Quanterness	Human	Teeth	M (ND)	-20.1	12.8	15.5	47.5	16.2	0.2	3.4	583.3
2594	Quanterness	Human	Teeth	M (ND)	-20.1	11.4	14.4	46.1	15.9	0.2	3.4	620.4
2595	Quanterness	Human	Teeth	M (ND)	-20.6	13.1	13.5	45.8	16.7	0.2	3.2	493.2
2596	Quanterness	Human	Teeth	M (ND)	-20.4	12.9	14.8	45.0	16.4	0.3	3.2	439.8

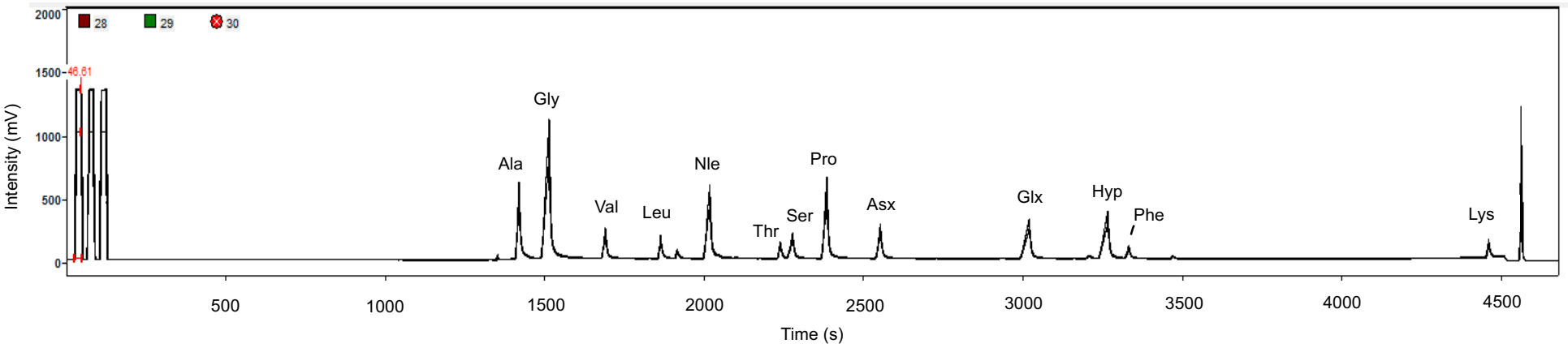
S2: Analytical results for all amino acids measured in the collagen samples of this study. Isotopic values are an average of triplicate measurements, the ± values are the standard deviation of the triplicate measurements.

Table S2: Nitrogen isotope results for all Scottish samples

S-SFU #	2586	2587	2588	2590	2591	2592	2593	2594	2595	2596	3595	3596	3597
species	human	human	human	human	human	human	human	human	human	human	pig	pig	human
Bulk $\delta^{15}N$ (‰)	12.0	10.2	11.5	11.0	13.0	9.8	12.8	11.4	13.1	12.9	4.6	4.0	15.2
alanine	14.2 ± 0.3	11.9 ± 0.0	12.9 ± 0.2	11.1 ± 0.0	14.5 ± 1.0	11.3 ± 0.1	15.1 ± 0.8	13.3 ± 0.4	15.1 ± 0.2	14.5 ± 0.9	5.3 ± 0.6	4.7 ± 0.5	20.9 ± 0.3
glycine	11.9 ± 0.2	9.4 ± 0.1	9.6 ± 0.1	9.1 ± 0.1	11.9 ± 0.7	8.3 ± 0.0	12.0 ± 0.3	10.3 ± 0.1	12.1 ± 0.1	13.0 ± 0.4	3.0 ± 0.5	2.1 ± 0.4	13.9 ± 0.5
valine	15.4 ± 0.8	12.3 ± 0.5	12.9 ± 0.3	12.7 ± 0.7	13.8 ± 0.6	12.2 ± 0.2	14.3 ± 0.4	12.6 ± 0.1	14.3 ± 0.2	13.3 ± 0.6	11.0 ± 1.7	10.8 ± 0.4	19.8 ± 1.1
leucine	13.5 ± 0.2	10.6 ± 0.6	11.1 ± 0.6	10.7 ± 0.4	12.7 ± 0.9	10.3 ± 0.1	12.5 ± 0.2	11.1 ± 0.0	12.7 ± 0.7	11.3 ± 0.9	7.1 ± 1.2	6.0 ± 1.1	20.1 ± 1.0
norleucine	-2.0 ± 0.1	-2.9 ± 0.2	-3.2 ± 0.2	-3.6 ± 0.1	-4.1 ± 0.8	-3.2 ± 0.3	-2.9 ± 0.4	-3.6 ± 0.0	-2.8 ± 0.1	-2.7 ± 0.4	-2.0 ± 0.6	-2.1 ± 0.3	-2.0 ± 0.5
threonine	-11.3 ± 0.7	-14.2 ± 0.3	-13.6 ± 0.8	-15.2 ± 1.1	-14.2 ± 0.9	-14.7 ± 0.6	-12.3 ± 0.6	-14.1 ± 0.8	-13.7 ± 0.1	-14.2 ± 0.9	-11.2 ± 0.7	-13.2 ± 0.9	-14.7 ± 0.2
serine	10.0 ± 0.8	8.7 ± 0.4	9.8 ± 0.3	8.9 ± 0.2	11.1 ± 0.6	7.7 ± 0.2	10.2 ± 1.1	9.0 ± 0.4	11.8 ± 1.2	11.1 ± 1.2	2.2 ± 0.4	1.4 ± 0.6	15.6 ± 0.7
proline	14.9 ± 0.4	13.1 ± 0.2	13.6 ± 0.2	13.5 ± 0.3	14.2 ± 0.8	11.8 ± 0.2	14.9 ± 0.4	13.8 ± 0.3	14.6 ± 0.2	14.5 ± 0.4	8.4 ± 0.2	8.0 ± 0.4	23.4 ± 0.6
aspartic acid	14.3 ± 0.7	11.8 ± 0.1	12.6 ± 0.2	11.6 ± 0.4	13.0 ± 1.1	11.2 ± 0.6	14.2 ± 0.4	11.8 ± 0.4	14.8 ± 0.3	13.5 ± 0.9	8.8 ± 0.3	8.2 ± 0.3	21.1 ± 0.6
glutamic acid	15.6 ± 0.2	13.3 ± 0.4	14.6 ± 0.2	13.5 ± 0.5	15.2 ± 1.0	12.8 ± 0.1	15.9 ± 0.5	14.2 ± 0.1	16.9 ± 0.2	15.3 ± 1.0	8.1 ± 0.2	7.7 ± 0.6	23.2 ± 0.6
hydroxyproline	14.4 ± 0.4	12.8 ± 0.2	13.9 ± 0.2	13.5 ± 0.4	14.0 ± 1.2	11.9 ± 0.4	14.6 ± 0.5	13.1 ± 0.7	14.5 ± 0.2	14.6 ± 0.7	8.7 ± 0.6	9.1 ± 0.7	22.7 ± 1.0
phenylalanine	7.9 ± 0.7	6.9 ± 0.6	7.2 ± 0.8	4.9 ± 1.5	5.5 ± 1.1	5.6 ± 0.8	7.0 ± 0.9	5.9 ± 0.8	8.1 ± 0.7	6.0 ± 2.6	7.6 ± 1.1	6.6 ± 1.6	4.9 ± 0.8
lysine	2.0 ± 0.9	0.1 ± 0.4	1.1 ± 1.6	-0.1 ± 0.7	-0.3 ± 2.5	-1.7 ± 0.7	3.0 ± 0.7	1.3 ± 1.3	1.6 ± 1.9	-1.9 ± 1.6	0.7 ± 0.4	0.1 ± 0.5	7.6 ± 0.7

S-SFU #	3598	3599	3600	3601	3602	3603	3604	3605	3606	3607	3609	3611
species	human	human	human	human	human	human	human	human	human	human	human	human
Bulk $\delta^{15}N$ (‰)	15.3	10.8	10.6	11.6	10.5	11.3	10.5	10.4	11.3	11.1	10.0	9.8
alanine	21.5 ± 0.6	15.5 ± 0.3	13.7 ± 0.1	14.7 ± 0.2	13.1 ± 0.2	13.0 ± 0.6	12.8 ± 0.1	12.0 ± 0.4	13.6 ± 0.5	13.4 ± 0.2	13.0 ± 0.6	11.7 ± 0.2
glycine	13.8 ± 0.5	12.2 ± 0.1	12.0 ± 0.2	13.9 ± 0.4	11.4 ± 0.0	12.0 ± 0.7	10.9 ± 0.3	10.9 ± 0.1	12.8 ± 0.1	12.6 ± 0.1	10.1 ± 0.2	10.0 ± 0.2
valine	20.3 ± 0.6	17.2 ± 0.3	14.5 ± 0.3	15.5 ± 0.6	13.7 ± 0.4	14.2 ± 0.5	13.7 ± 0.3	13.3 ± 0.3	14.5 ± 0.4	14.7 ± 0.3	13.5 ± 0.1	13.7 ± 0.4
leucine	20.1 ± 0.7	15.5 ± 0.2	11.9 ± 0.9	14.3 ± 0.7	12.6 ± 0.5	11.7 ± 1.2	12.2 ± 0.5	10.5 ± 0.8	12.5 ± 0.7	13.7 ± 0.4	11.5 ± 0.3	11.8 ± 1.2
norleucine	-2.3 ± 0.3	-1.7 ± 0.1	-2.1 ± 0.1	-2.0 ± 0.4	-2.4 ± 0.1	-3.7 ± 0.7	-3.5 ± 0.4	-2.6 ± 0.5	-2.9 ± 0.2	-2.3 ± 0.2	-2.8 ± 0.4	-2.7 ± 0.2
threonine	-15.3 ± 2.2	7.5 ± 1.0	-13.5 ± 2.8	-12.2 ± 1.1	-12.2 ± 0.9	-13.4 ± 1.3	-1.8 ± 1.0	-13.6 ± 1.3	-13.5 ± 0.7	-13.6 ± 1.0	-13.5 ± 0.4	-14.9 ± 0.3
serine	15.6 ± 0.6	2.5 ± 1.5	10.0 ± 0.5	5.5 ± 0.6	1.7 ± 1.3	9.2 ± 0.3	9.9 ± 1.3	9.0 ± 0.6	11.9 ± 1.0	8.4 ± 2.8	7.8 ± 2.8	8.4 ± 1.3
proline	22.3 ± 0.4	15.1 ± 0.2	15.2 ± 0.1	15.5 ± 0.3	15.1 ± 0.2	13.8 ± 0.8	13.8 ± 0.3	14.5 ± 0.2	14.7 ± 0.2	14.9 ± 0.1	14.4 ± 0.4	13.8 ± 0.1
aspartic acid	20.0 ± 0.6	16.2 ± 0.4	15.1 ± 0.5	16.9 ± 0.1	14.6 ± 0.4	13.3 ± 0.5	14.0 ± 0.3	13.3 ± 0.7	14.8 ± 0.4	14.6 ± 0.9	14.6 ± 0.3	13.9 ± 1.1
glutamic acid	22.4 ± 0.3	16.6 ± 0.3	16.2 ± 0.1	17.1 ± 0.2	15.5 ± 0.5	13.9 ± 0.5	15.2 ± 0.7	14.9 ± 0.3	16.5 ± 0.3	16.5 ± 0.2	15.5 ± 0.3	15.3 ± 0.4
hydroxyproline	22.2 ± 0.5	15.2 ± 0.4	15.0 ± 0.1	15.3 ± 0.2	14.4 ± 0.1	12.1 ± 0.1	13.6 ± 0.4	13.9 ± 0.2	14.2 ± 0.3	14.3 ± 0.1	14.1 ± 0.3	13.3 ± 0.4
phenylalanine	5.9 ± 1.5	10.4 ± 0.3	8.7 ± 0.2	9.1 ± 0.4	7.2 ± 1.1	5.3 ± 0.7	5.1 ± 2.7	6.7 ± 0.8	8.1 ± 0.9	8.9 ± 1.1	6.3 ± 1.5	5.1 ± 1.2
lysine	8.0 ± 0.5	3.8 ± 1.0	3.2 ± 0.3	4.9 ± 0.2	2.7 ± 1.2	0.2 ± 0.2	1.6 ± 1.2	1.6 ± 0.8	3.7 ± 0.3	2.5 ± 0.6	2.5 ± 1.2	1.8 ± 0.6

S3: Typical N_2 gas chromatogram of NAIP ester derivatized amino acids from bone collagen (S-SFU 2593). Ala = alanine, Gly = glycine, Val = valine, Leu = leucine, Nle = norleucine, Thr = threonine, Ser = serine, Pro = proline, Asx = aspartic acid, Glx = glutamic acid, Hyp = hydroxyproline, Phe = phenylalanine, Lys = lysine.



S4: Analytical results for QC collagen standards in comparison with long-term average values. Isotopic values are an average of triplicate measurements, the ± values are the standard deviation of the triplicate measurements.

Table S4: Nitrogen isotope results for collagen QC samples (SRM-1, SRM-2, and SRM-3) from the three analytical sessions.

	SRM-1 (seal) $\delta^{15}N$ (‰)												SRM-2 (deer) $\delta^{15}N$ (‰)									SRM-3 (fish) $\delta^{15}N$ (‰)											
	24-May-23			29-May-23			05-Jul-23			longterm avg			24-May-23			05-Jul-23			longterm avg			24-May-23			29-May-23			05-Jul-23			05-Jul-23			longterm avg		
										(n=22)									(n=19)															(n=19)		
Ala	27.0	±	0.5	28.3	±	0.3	23.8	±	0.9	25.5	±	1.5	1.2	±	0.1	2.1	±	0.5	2.5	±	0.8	9.1	±	0.3	9.3	±	0.3	9.4	±	0.0	8.7	±	0.3	9.8	±	1.0
Gly	13.0	±	0.6	13.5	±	0.1	10.6	±	0.0	12.2	±	1.1	-3.0	±	0.1	-3.1	±	0.6	-2.0	±	0.9	8.6	±	0.0	8.5	±	0.2	7.6	±	0.1	7.7	±	0.1	8.5	±	1.2
Val	25.3	±	0.9	25.4	±	0.3	21.8	±	0.4	25.0	±	1.7	6.9	±	0.1	7.0	±	0.6	7.0	±	1.3	13.0	±	0.7	12.9	±	0.5	14.5	±	0.4	11.0	±	0.5	12.4	±	1.1
Leu	28.4	±	1.9	29.5	±	0.3	25.5	±	0.2	27.1	±	1.5	-0.4	±	0.5	1.5	±	0.8	1.9	±	1.0	9.3	±	0.2	9.9	±	0.9	9.1	±	1.2	8.8	±	0.5	9.9	±	1.0
Nle	-1.9	±	0.5	-1.6	±	0.2	-2.7	±	0.4	-1.1	±	1.0	-3.5	±	0.4	-3.0	±	0.7	-1.8	±	1.0	-2.2	±	0.4	-3.1	±	0.1	-2.3	±	0.9	-3.0	±	0.7	-1.8	±	1.1
Thr	-25.6	±	0.3	-27.2	±	0.3	-23.9	±	1.5	-22.8	±	4.3	-15.2	±	0.8	-14.7	±	0.4	-12.9	±	2.6	-5.0	±	0.7	-4.4	±	0.8	-2.9	±	0.5	-3.9	±	0.7	-3.2	±	1.9
Ser	17.0	±	0.8	8.1	±	1.3	17.2	±	0.7	15.4	±	4.2	-8.7	±	2.8	-5.8	±	3.8	-3.9	±	3.1	7.6	±	0.6	4.3	±	1.7	5.1	±	1.1	6.1	±	0.6	6.5	±	2.5
Pro	29.1	±	0.8	29.7	±	0.3	25.2	±	0.2	26.6	±	1.6	4.2	±	0.3	3.1	±	0.8	4.5	±	0.8	12.7	±	0.1	12.8	±	0.3	11.3	±	0.0	11.0	±	0.4	11.9	±	1.0
Asx	24.9	±	1.0	26.0	±	0.2	21.2	±	0.6	22.9	±	1.4	3.3	±	0.6	2.2	±	0.7	3.8	±	0.8	11.2	±	0.1	11.0	±	0.0	10.0	±	0.1	9.2	±	0.5	10.3	±	1.1
Glx	30.2	±	0.8	31.1	±	0.3	25.7	±	0.1	27.5	±	1.7	4.4	±	0.5	3.0	±	1.0	4.7	±	1.0	12.3	±	0.2	12.8	±	0.4	11.2	±	0.1	10.5	±	0.2	11.6	±	1.3
Hyp	29.5	±	1.0	30.2	±	0.2	25.4	±	0.5	26.5	±	1.8	3.3	±	0.3	1.6	±	1.7	4.1	±	1.0	13.6	±	0.1	12.2	±	0.2	10.7	±	0.0	11.0	±	0.2	11.5	±	1.2
Phe	9.7	±	0.9	9.7	±	0.7	9.1	±	1.2	8.4	±	4.0	2.8	±	0.9	2.5	±	0.9	2.7	±	2.4	8.4	±	0.9	6.7	±	0.6	9.7	±	1.3	7.6	±	1.4	7.6	±	2.8
Lys	8.3	±	0.9	8.9	±	0.4	4.9	±	1.1	8.4	±	1.1	-5.3	±	0.8	-6.0	±	1.5	-3.4	±	1.3	3.5	±	0.9	4.1	±	1.2	3.0	±	0.4	3.0	±	0.7	4.0	±	1.1

S5: Analytical results for the QCmix standard in comparison with longterm average values. Isotopic values are an average of triplicate measurements, the ± values are the standard deviation of the triplicate measurements.

Table S5: Nitrogen isotope results for QCmix from the three analytical sessions.

	QCmix $\delta^{15}N$ (‰)																					
	24-May-23			24-May-23			29-May-23			29-May-23			05-Jul-23			05-Jul-23			longerm avg (n=40)			Expected values
Gly	22.1	±	0.4	22.7	±	0.3	23.0	±	0.4	24.0	±	0.2	19.4	±	0.2	19.7	±	0.1	21.4	±	1.4	20.7
Val	26.4	±	1.3	28.2	±	0.1	29.6	±	0.6	30.1	±	0.6	25.1	±	0.8	24.7	±	0.3	27.9	±	1.6	30.2
Nle	-2.1	±	0.4	-1.0	±	0.1	-2.5	±	0.2	-2.1	±	0.3	-2.8	±	0.1	-2.5	±	0.3	-1.5	±	0.7	-2.0
Pro	-0.1	±	0.6	0.9	±	0.2	0.1	±	0.4	0.6	±	0.6	-0.7	±	0.7	-0.4	±	0.0	0.5	±	0.7	0.6
Glx	-5.9	±	0.6	-5.0	±	0.1	-5.4	±	0.5	-5.4	±	0.1	-6.3	±	0.9	-5.6	±	0.3	-4.2	±	1.1	-4.5

S6:

To ensure there are no errors in collagen preservation, derivatization, or instrument performance (Ma et al., 2021; O'Connell and Collins, 2018; Roberts et al., 2018; Soncin et al., 2021), we compared the $\delta^{15}N$ values of the amino acids proline (Pro) and hydroxyproline (Hyp). Because Pro derives from the hydroxylation of Hyp without a C or N atom exchange, the $\delta^{15}N$ values of Pro and Hyp are expected to show proportional correlations (i.e., close to $R^2=1$) if the quality of the AA data is good. The $\delta^{15}N_{Hyp}$ and $\delta^{15}N_{Pro}$ values obtained in our study show an R^2 value of 0.97, thus indicating good quality of the data.