A REPORT ON PHASE 2 OF THE FIFTH INTERNATIONAL RADIOCARBON INTERCOMPARISON (VIRI)

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ABSTRACT. The Fifth International Radiocarbon Intercomparison (VIRI) continues the tradition of the TIRI (third) and FIRI (fourth) (Scott 2003) intercomparisons and operates in addition to any within-laboratory quality assurance measures as an independent check on laboratory procedures. VIRI is a phased intercomparison; results for the first phase, which employed grain samples, were reported in Scott et al. (2007). The second phase, involving bone samples, is reported here. The third and final phase, which includes samples of peat, wood, and shell, has also been completed and a companion paper appears in these proceedings.

Five bone samples were made available and included Sample E: mammoth bone (>5 half-lives); Sample F: horse bone (from Siberia, excavated in 2001; and Samples H and I: whale bones (approximately 2 half-lives). Sample G (human bone) was accessible only to accelerator mass spectrometry (AMS) laboratories because of the limited amount of sample available. More than 40 laboratories participated in Phase 2 and consensus values for the ages were as follows: Sample E = 39,305 ^{14}C yr BP (standard deviation [1 σ] = 121 yr); Sample F = 2513 yr BP (1 σ = 5 yr); Sample G = 969 yr BP (1 σ = 5 yr); Sample H = 9528 yr BP (1 σ = 7 yr); and Sample I = 8331 yr BP (1 σ = 6 yr). Sample G had previously been dated by 4 laboratories and a weighted mean of 934 ± 12 yr BP had been quoted. Sample I had previously been dated at 8335 ± 25 yr BP and Sample H had been dated at 9565 ± 130 yr BP. Results for Sample H and Sample I are in good agreement with the previous results; Sample G results, however, give a value that is significantly older than the previously reported results.

INTRODUCTION

The Fifth International Radiocarbon Intercomparison (VIRI) has continued the tradition of the TIRI (third) and FIRI (fourth) intercomparisons (Scott 2003) as a ^{14}C community project, with samples provided by participants and a substantial participation rate. Over the 4-yr lifetime of VIRI, the first suite of samples (grain) was sent out in September 2004. The second suite of samples comprised bone and was distributed in October 2005, with results returned by late 2006. The final suite of samples included a wide variety of materials and was completed in 2008.

Not all laboratories that had previously participated in Phase 1 participated in Phase 2, since bone is not a routinely measured sample in all laboratories. A total of 42 laboratories, identified in Table 1, reported results. As always, the actual number of results submitted was greater than the number of laboratories since several laboratories submitted results using several independent systems. As a consequence, more than 60 sets of results were returned. One of the difficulties reported, especially for the radiometric laboratories, was that the sample size did not meet their routine requirements. For radiometric laboratories, we had distributed samples ranging from 60–100 g. A few laboratories also reported difficulty with the sample pretreatment (specifically, collagen extraction).

Sample Descriptions

Sample E: Mammoth Bone (>5 half-lives)

This bone is from a site called Quartz Creek, Dawson City, Yukon Territory. The bone is a portion of the pelvis of a *Mammuthus* sp. specimen. The sample was collected in August 2003 by Ross Barnett of the Zoology Department, University of Oxford. It was supplied by Tom Higham of ORAU. In an initial test of the material, 0.58 g of collagen was recovered from 5 g of bone. The % carbon of this collagen sample was 41%.

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Table 1 Participating laboratories.

Lab name	Lab method[a]	Country
Laboratorio de Tritio y Radiocarbone, La Plata	LSC	Argentina
ANSTO	AMS	Australia
VERA, University of Vienna	AMS	Austria
Belarus Academy of Science	LSC	Belarus
Royal Institute for Cultural Heritage	AMS	Belgium
Aarhus AMS Dating Laboratory	AMS	Denmark
Dating Laboratory, University of Helsinki	AMS	Finland
Centre de Datation par le Radiocarbone, Lyon	AMS, LSC	France
Heidelberg Akademie der Weissenschaften	GPC	Germany
Radiocarbon Laboratory, Cologne	GPC	Germany
AMS Laboratory, Erlangen	AMS	Germany
Leibniz Institute for Applied Geosciences, Hannover	GPC	Germany
Leibniz Labor, Kiel	AMS	Germany
Laboratory of Environmental Studies of INR/HAS	GPC	Hungary
CEDAD, University of Lecce	AMS	Italy
ENEA	LSC	Italy
CIRCE, 2nd University Naples	AMS	Italy
Weizmann Institute	AMS	Israel
Centre for Chronological Research, Nagoya University	AMS	Japan
University Museum, University of Tokyo	AMS	Japan
Universiteit Utrecht	AMS	Netherlands
Centre for Isotope Study, Groningen	AMS, GPC	Netherlands
Rafter Radiocarbon Laboratory	AMS	New Zealand
University of Waikato	AMS, LSC	New Zealand
Radiocarbon Lab, Trondheim	AMS	Norway
Poznań Radiocarbon Laboratory	AMS	Poland
Kraków Radiocarbon Laboratory	LSC	Poland
Gliwice Radiocarbon Laboratory	GPC, AMS	Poland
Radiocarbon Laboratory, Russian Academy of Sciences	LSC	Russia
Radiocarbon Lab, Geographical Institute, St. Petersburg	LSC	Russia
Radiocarbon Lab, Barcelona	LSC	Spain
Laboratorio de Datacion, Universidad de Granada	LSC	Spain
Tandem Laboratory, Uppsala University	AMS	Sweden
ETH/PSI, Zurich	AMS	Switzerland
National Taiwan University	LSC	Taiwan
Oxford Radiocarbon Accelerator lab	AMS	UK
SUERC	AMS	UK
Ukraine Academy of Sciences, Kiev	LSC	Ukraine
Applied Isotope Studies, Georgia	AMS	USA
KCCAMS, University of California	AMS	USA
NOSAMS, WHOI	AMS	USA
Arizona AMS facility	AMS	USA

[a]AMS = accelerator mass spectrometry; GPC = gas proportional counting; LSC = liquid scintillation counting.

Sample F: Horse Bone (<1 half-life)

This sample was excavated in 2001 and provided by Ganna Zaitseva of the Institute of History of Material Culture, St. Petersburg, Russia. It is from an archaeological investigation of a Scythian burial site in Siberia. Some 0.34 g of collagen was recovered from 1.67 g of bone. The % carbon of this sample was 30.3%.

Sample G: Human Bone

This is a sample from a young female buried with a neonate in a waterlogged dendro-dated coffin and was provided by Alex Bayliss of English Heritage. This sample was sent to AMS laboratories only.

Sample H: Whale Bone (approximately 2 half-lives)

This whale bone sample was submitted to the University of Washington in August 1983 and is the jawbone of a whale recovered from sand deposits within a raised beach at Svalbard, Spitsbergen, Norway. It was provided by Paula Reimer of Queen's University, Belfast.

Sample I: Whale Bone (approximately 2 half-lives)

This whale bone is from the cranium of a whale (species not determined) found in August 1997 on Svalbard, and provided by Steinar Gulliksen of the National Dating Laboratory, Trondheim.

Table 2a Results for Sample E.

Lab code	Lab type	Age (yr BP)	Error (yr BP)	$\delta^{13}C$ (‰)
3	GPC	42,060	850	–21.70
4	AMS	37,000	1000	–21.20
5	AMS	40,700	1200	–21.80
5	AMS	40,330	1000	–23.50
7	LSC	34,150	1120	–21.20
8	AMS	39,790	1160	–20.60
11	LSC	25,530	500	–21.00
12	AMS	>41,000	*	–21.10
13	AMS	35,100	700	–31.80
13	AMS	42,300	2400	–21.50
15	GPC	35,550	600	–22.00
16	AMS	41,139	1041	–20.80
22	AMS	41,350	450	–20.60
22	AMS	39,950	500	–20.30
22	AMS	40,300	500	–19.50
22	AMS	40,450	370	–20.10
23	AMS	35,700	500	–20.90
25	AMS	40,320	760	–20.90
25	AMS	40,490	910	–21.00
26	AMS	41,500	1400	–21.30
27	GPC	39,950	410	–20.50
30	LSC	35,339	715	–22.40
31	LSC	35,500	400	–16.80
32	LSC	22,810	300	–20.00
37	AMS	39,000	300	–20.60
37	AMS	36,400	310	–20.90
38	LSC	24,300	650	–15.80
39	AMS	36,312	370	–18.60
40	LSC	26,550	700	–21.43
41	GPC	>42,000	*	–20.00
42	GPC	32,570	720	–24.00
43	AMS	40,350	1150	–20.90
43	AMS	40,100	1150	–20.90
44	AMS	40,809	2239	–21.00

Table 2a Results for Sample E. *(Continued)*

Lab code	Lab type	Age (yr BP)	Error (yr BP)	$\delta^{13}C$ (‰)
44	AMS	40,133	1622	–23.40
45	AMS	36,300	250	–28.00
45	AMS	35,180	180	–31.00
45	AMS	34,690	170	–21.00
47	AMS	42,300	1300	–21.10
47	AMS	41,100	800	–21.10
50	GPC	35,680	690	–20.80
51	LSC	22,660	1060	*
53	AMS	37,850	1100	–21.50
56	LSC	38,347	511	–23.40
57	AMS	38,183	314	–21.01
60	AMS	36,840	230	–22.20
62	AMS	39,340	580	–21.17
62	AMS	36,440	2590	–22.23
62	AMS	37,960	500	–18.71
63	AMS	33,230	300	–22.60
64	AMS	42,500	3135	–21.50
66	LSC	>35,300	*	–20.96
73	AMS	38,630	840	–20.50
76	AMS	39,600	350	–21.00
77	LSC	21,684	720	–21.00
78	AMS	33,020	690	–21.00
80	LSC	>25,400		–20.00
82	AMS	>37,200	*	–20.20

Table 2b Results for Sample F.

Lab code	Lab type	Age (yr BP)	Error (yr BP)	$\delta^{13}C$ (‰)
3	GPC	2585	15	–21.10
4	AMS	2485	35	–20.30
5	AMS	2540	35	–20.70
5	AMS	2500	45	–24.30
7	LSC	2450	45	–20.47
8	AMS	2490	30	–20.70
11	LSC	2450	80	–20.80
12	AMS	2765	35	–20.70
13	AMS	2500	35	–26.80
13	AMS	2620	40	–18.60
15	GPC	2440	25	–21.00
16	AMS	2577	36	–20.20
22	AMS	2509	29	–20.00
22	AMS	2530	31	–19.90
23	AMS	2500	32	–20.50
25	AMS	2520	20	–20.30
25	AMS	2530	20	–20.00
26	AMS	2581	25	–20.60
27	GPC	2570	30	–20.20
30	LSC	2865	62	–20.70
31	LSC	2740	40	–16.00

Table 2b Results for Sample F. *(Continued)*

Lab code	Lab type	Age (yr BP)	Error (yr BP)	$\delta^{13}C$ (‰)
37	AMS	2540	30	–20.10
37	AMS	2550	35	–20.20
38	LSC	3040	75	–15.00
39	AMS	2488	40	–18.10
40	LSC	2470	80	–21.14
41	GPC	4570	100	–20.00
43	AMS	2480	55	–20.30
43	AMS	2498	34	–20.31
44	AMS	2568	43	–20.60
44	AMS	2477	37	–22.60
45	AMS	2535	25	–21.00
45	AMS	2484	26	–22.00
47	AMS	2495	35	–20.60
47	AMS	2540	35	–20.40
50	GPC	2475	30	–20.30
51	LSC	2270	140	*
53	AMS	2540	30	–19.90
56	LSC	2545	30	–22.60
57	AMS	2517	44	–20.64
60	AMS	2475	25	–20.30
62	AMS	2485	25	–21.09
62	AMS	2405	35	–21.48
62	AMS	2550	30	–19.48
63	AMS	2640	45	–14.70
64	AMS	2480	35	–20.40
66	LSC	2555	35	–20.98
73	AMS	2480	40	–20.10
75	AMS	2414	39	–21.90
76	AMS	2537	18	–27.00
78	AMS	2435	60	–20.10
80	LSC	2970	70	–20.00
82	AMS	2690	100	–19.60

Table 2c Results for Sample G.

Lab code	Lab type	Age (yr BP)	Error (yr BP)	$\delta^{13}C$ (‰)
4	AMS	955	30	–20.40
5	AMS	1010	40	–21.40
5	AMS	930	50	–22.90
8	AMS	1080	25	–19.90
12	AMS	1385	30	–21.30
13	AMS	980	30	–24.20
13	AMS	1205	30	–17.40
16	AMS	982	30	–19.80
22	AMS	946	26	–19.50
22	AMS	962	28	–19.40
23	AMS	1007	42	–20.00
25	AMS	985	20	–19.80
25	AMS	985	15	–20.00
26	AMS	1017	23	–20.20

Table 2c Results for Sample G. *(Continued)*

Lab code	Lab type	Age (yr BP)	Error (yr BP)	$\delta^{13}C$ (‰)
37	AMS	940	40	–19.80
39	AMS	842	45	–28.30
43	AMS	952	30	–19.91
43	AMS	917	32	–19.96
44	AMS	1035	32	–19.80
45	AMS	980	24	–21.00
47	AMS	975	35	–20.10
47	AMS	1050	35	–19.80
53	AMS	970	30	*
55	AMS	975	45	–21.00
57	AMS	1104	42	–19.92
60	AMS	935	25	–15.80
62	AMS	930	20	–20.88
62	AMS	1470	70	–22.07
62	AMS	950	20	–19.55
63	AMS	980	40	–19.20
64	AMS	890	30	–20.30
73	AMS	945	35	–19.80
75	AMS	910	25	–20.80
76	AMS	1016	17	–19.00
78	AMS	900	60	–19.80
82	AMS	1110	90	–21.80

Table 2d Results for Sample H.

Lab code	Lab type	Age (yr BP)	Error (yr BP)	$\delta^{13}C$ (‰)
3	GPC	9540	25	–17.00
4	AMS	9510	35	–16.80
5	AMS	9540	40	–15.90
5	AMS	9530	50	–15.80
7	LSC	9480	70	–16.60
8	AMS	9365	50	–16.30
11	LSC	8770	120	–16.30
12	AMS	9725	65	–16.30
13	AMS	9290	50	–17.30
13	AMS	9560	60	–17.10
15	GPC	9580	45	–16.80
16	AMS	9518	43	–16.20
22	AMS	9545	40	–15.90
22	AMS	9690	45	–16.00
22	AMS	9573	40	–15.50
23	AMS	9500	70	–16.60
25	AMS	9525	20	–16.40
25	AMS	9555	25	–16.00
26	AMS	9592	38	–16.60
27	GPC	9485	45	–16.20
30	LSC	9581	67	–17.00
31	LSC	9510	60	–11.30
32	LSC	9250	100	–15.00
37	AMS	9490	40	–16.30

Table 2d Results for Sample H. *(Continued)*

Lab code	Lab type	Age (yr BP)	Error (yr BP)	$\delta^{13}C$ (‰)
37	AMS	9530	50	–16.30
37	AMS	9470	45	–16.30
37	AMS	9590	50	–16.30
38	LSC	9880	170	–11.20
39	AMS	9476	55	–10.10
40	LSC	8700	110	–16.75
41	GPC	4810	130	–20.00
41	GPC	5220	180	*
41	GPC	4950	105	*
42	GPC	9520	45	–18.10
43	AMS	9485	55	–16.36
43	AMS	9455	50	–16.22
44	AMS	9682	53	–16.10
44	AMS	9617	49	–17.20
45	AMS	9435	33	–17.00
47	AMS	9645	40	–16.60
47	AMS	9610	40	–15.90
50	GPC	9490	50	–16.20
51	LSC	10,150	380	*
53	AMS	9545	35	–15.90
56	LSC	9491	45	–17.20
57	AMS	9372	56	–16.55
60	AMS	9520	35	–13.00
62	AMS	9640	35	–15.31
62	AMS	9195	40	–19.11
62	AMS	9560	40	–16.11
64	AMS	9560	60	–16.70
66	LSC	9435	45	–16.41
73	AMS	9560	60	–16.80
75	AMS	8891	58	–17.20
78	AMS	9250	80	–16.40
80	LSC	9420	120	–20.00
82	AMS	9790	240	–17.30

Table 2e Results for Sample I.

Lab code	Lab type	Age (yr BP)	Error (yr BP)	$\delta^{13}C$ (‰)
3	GPC	8410	20	–17.00
4	AMS	8255	35	–16.60
5	AMS	8375	35	–16.40
5	AMS	8345	45	–19.50
7	LSC	8390	60	–16.70
8	AMS	8400	40	–17.10
11	LSC	7940	90	–16.60
12	AMS	8300	50	–16.70
13	AMS	8340	50	–13.60
13	AMS	8300	60	–17.50
15	GPC	8300	35	–16.50
16	AMS	8300	33	–16.40
22	AMS	8336	40	–16.20

Table 2e Results for Sample I. *(Continued)*

Lab code	Lab type	Age (yr BP)	Error (yr BP)	$\delta^{13}C$ (‰)
22	AMS	8380	40	–16.00
22	AMS	8451	36	–15.80
23	AMS	8320	47	–16.90
25	AMS	8335	20	–16.80
25	AMS	8355	25	–17.00
26	AMS	8357	36	–17.10
27	GPC	8355	40	–16.20
28	LSC	8370	240	*
30	LSC	8494	99	–19.10
31	LSC	8590	50	–12.10
32	LSC	8290	100	–15.00
37	AMS	8220	50	–16.20
37	AMS	8290	55	–16.00
37	AMS	8360	40	–16.20
37	AMS	8390	40	–16.70
38	LSC	8700	115	–10.70
39	AMS	8262	50	–22.80
40	LSC	8030	110	–17.02
41	GPC	7550	110	–20.00
42	GPC	8300	45	–18.10
43	AMS	8350	47	–16.73
43	AMS	8290	50	–16.80
44	AMS	8411	50	–16.50
44	AMS	8318	43	–18.50
45	AMS	8194	31	–17.00
45	AMS	8268	31	–17.00
47	AMS	8340	40	–16.30
47	AMS	8380	35	*
50	GPC	8280	40	–16.50
53	AMS	8295	35	–17.20
56	LSC	8360	37	–18.50
57	AMS	9066	55	–16.47
60	AMS	8260	35	–16.40
62	AMS	8345	35	–17.79
62	AMS	8485	45	–19.52
62	AMS	8280	35	–16.34
63	AMS	7990	55	–18.90
64	AMS	8330	50	–16.80
66	LSC	8330	45	–16.72
73	AMS	8320	60	–15.70
75	AMS	7739	59	–18.20
76	AMS	8372	19	–19.00
77	LSC	8144	142	–18.00
78	AMS	8150	95	–17.00
80	LSC	8890	100	–20.00
82	AMS	8610	210	–13.25

RESULTS

In the analyses reported here, the replicate results from individual laboratories have been included as though they were an independent set of results, an assumption that is not unreasonable. Table 1 lists the laboratories that took part in the study while Table 2 presents the results as reported for samples E–H. An * indicates that a piece of information is missing. All results are given in yr BP. For Sample E, a small number of laboratories reported the age in "greater than" format. Also, the quoted uncertainty for this sample was often asymmetric, but for simplicity in format, the larger of the 2 values has been quoted. For some laboratories (6 in total), the $\delta^{13}C$ was estimated, no adjustments have been made to the fractionation corrections, and the age results have not been adjusted.

Table 3 lists the summary statistics for each sample (including the mean, median, IQR [interquartile range], and range) for both ^{14}C age and $\delta^{13}C$. Table 4 provides a more in-depth summary of the results for the different laboratory types.

Table 3 Detailed summary statistics for each sample.

	n	Mean	Median	St dev	Q_1	Q_3	Min	Max	IQR	Range
Sample E										
$\delta^{13}C$	57	–21.43	–21.00	2.517	–21.60	–20.60	–31.80	–15.80		
Age (BP)	57	36,905	38,183	5085	35,320	40,400	21,684	42,500	5080	20,816
Sample F										
$\delta^{13}C$	52	–20.51	–20.40	2.032	–21.00	–20.02	–27.00	–14.70		
Age	52	2590	2525	306.6	2481	2569	2405	4570	88	2170
Sample G										
$\delta^{13}C$	35	–20.42	–19.96	1.961	–21.00	–19.80	–28.30	–15.80		
Age	35	1007	980	126.1	940	1017	842	1470	77	628
Sample H										
$\delta^{13}C$	54	–16.25	–16.33	1.69	–16.85	–16.00	–20.00	–10.10		
Age	55	9236	9518	1050	9435	9573	4810	9880	138	5070
Sample I										
$\delta^{13}C$	59	–22.57	–22.40	1.556	–23.20	–21.86	–29.80	–19.00		
Age	59	8325	8335	215.4	8280	8380	7550	9066	100	1516

It is notable that the interquartile range, IQR (Q_3–Q_1), is generally narrow while the standard deviation and full range show the full spread of the distribution, which can be impacted by outliers. The mean is a summary statistic that is relatively sensitive to outlying values, so the table includes the median, which is relatively robust.

Table 3 and Figure 1 highlight the presence of a number of statistical outliers and the effect they have on the results (i.e. the mean and median are different, and the range and standard deviation are large). Table 4 and Figure 1 clearly demonstrate the demographic shift, with many more AMS than radiometric results. Due to the small number of results for the GPC laboratories, the boxplots appear more stretched.

Outliers

It is clear that there are a small number of measurements or outliers that need to be screened; in a first informal analysis, these observations are marked on the boxplots. The criterion for identification (those marked by * on the boxplot) is any observation that lies more than 1.5 × IQR from the median. Up to 12% of the results for any 1 sample were identified as outliers (~10% of the total

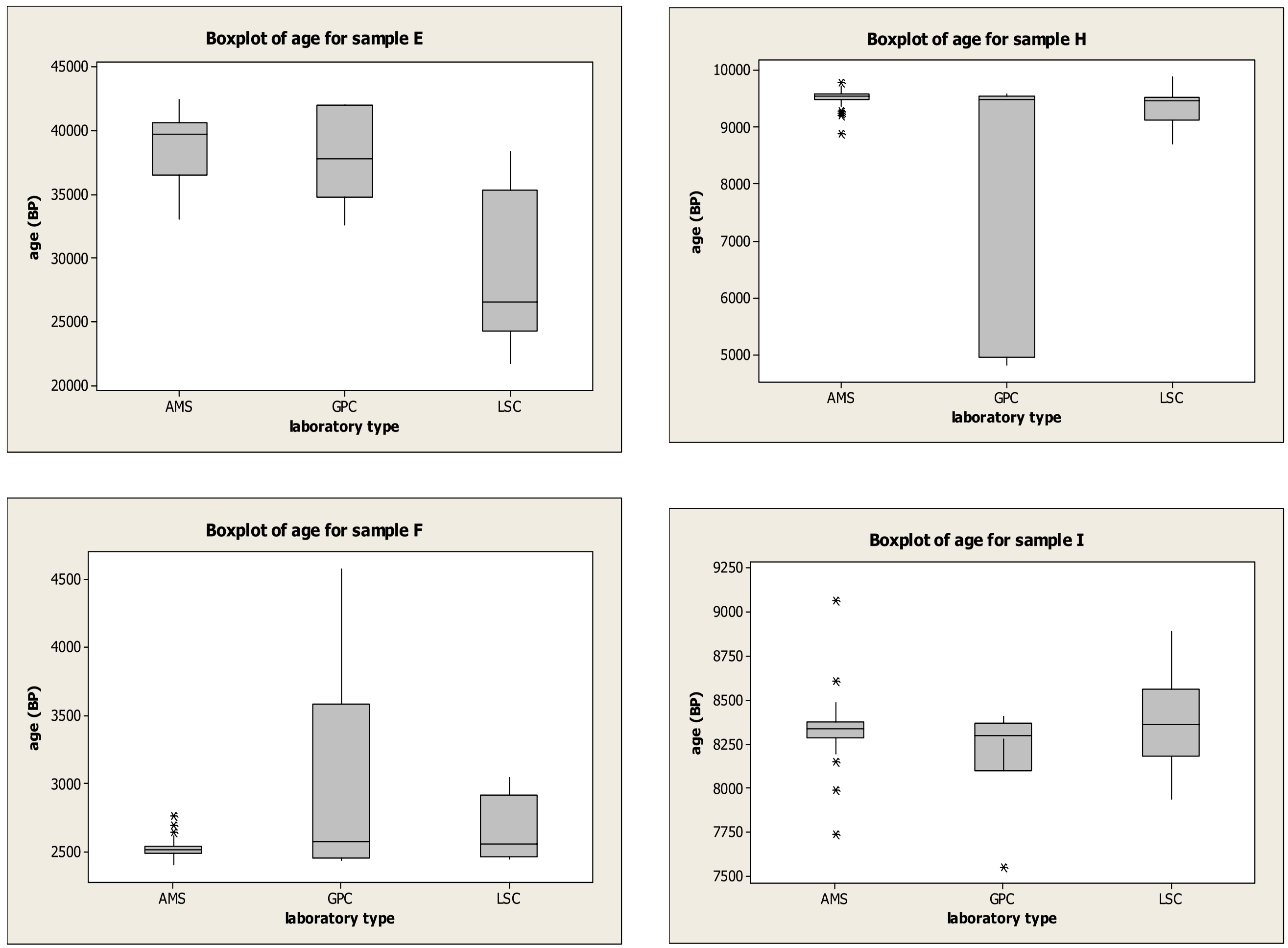

Figure 1 Boxplots of distribution of results by laboratory type (AMS, GPC, and LSC) for samples E–I (excluding G—AMS only). Outliers are marked by asterisks (*).

Table 4 Detailed summary statistics for each sample by laboratory type for samples E, F, H, and I.

	n	Mean	Median	St dev	Q_1	Q_3	Min	Max
Sample E								
AMS	40	38,772	39,695	2532	36,540	40,648	33,020	42,500
GPC	6	37,968	37,815	3928	34,805	42,015	32,570	42,060
LSC	11	29,537	26,550	6146	24,300	35,339	21,684	38,347
Sample F								
AMS	38	2525	2513	68.6	24,845	2542	2405	2765
GPC	5	2928	2570	920	2458	3578	2440	4570
LSC	9	2676	2555	233.2	2460	2917	2450	3040
Sample H								
AMS	38	9510	9535	158.4	9474	9590	8891	9790
GPC	7	7582	9485	2425	4950	9540	4810	9580
LSC	10	9352	9458	362	9130	9528	8700	9880
Sample I								
AMS	41	8328	8335	176.3	8285	8373	7739	9066
GPC	6	8199	8300	322	8098	8369	7550	8410
LSC	12	8377	8365	270.1	8180	8566	7940	8890

number), and these are listed in Table 5 below. When the results are summarized by laboratory type, the identified outliers change (as the distribution of results change). Interestingly, there is an increase in the relative percentage of outliers that are reported by AMS laboratories (as a direct result of the very small IQR). Omitting these measurements results in changes to the overall summary statistics and this is the basis for the preliminary consensus values shown in Table 6.

Table 5 Identification of outliers (L, G, and A represent, respectively, LSC, GPC, and AMS).

Sample	E	F	G	H	I
Nr of observations	57	52	35	55	59
Nr of outliers	6 (6L)	6 (4L, 1G, 1A)	3 (A)	3 (3G)	10 (5L, 1G, 4A)
Outliers	21684, 22810, 24300, 25400, 25530, 26550	2740, 2765, 2865, 2970, 3040, 4570	1205, 1385, 1470	4810, 4950, 5220	7550, 7739, 9940, 7990, 8030, 8590, 8610, 8700, 8890, 9066

In terms of collagen separation, most laboratories used the Longin (1971) method, with occasional modifications. There was no apparent effect of pretreatment method on the results.

There is general agreement in the results when comparing the different laboratory types (Table 6), with the possible exception of Sample E, but overall the results have also highlighted the number of individual outliers reported by the laboratories and the much-reduced IQR of results reported by AMS laboratories. Thus, the preliminary results show broad agreement across all laboratories, but there is clearly considerable scatter in the results when outliers are included. Outliers account for approximately 10% of the full set of results.

Known Age

Several of the samples had previously been dated and so there was some additional information concerning their age. For Sample G (human bone), this belonged to a 25-yr-old female buried with a

Table 6 Summary statistics for age with gross outliers omitted.

	n	Mean	Median	St dev	Q_1	Q_3	Min	Max
Sample E								
AMS	40	38,772	39,695	2532	36,540	40,648	33,020	42,500
GPC	6	37,968	37,815	3928	34,805	42,015	32,570	42,060
LSC	5	35,727	35,339	1560	34,725	36,924	34,150	38,347
overall	51	38,379	39,000	2754	35,700	42,500	32,570	42,500
Sample F								
AMS	37	2518	2509	56.5	2484	2540	2405	2690
GPC	4	2517	2522	71	2449	2581	2440	2585
LSC	5	2494	2470	51.9	2450	2550	2450	2555
overall	46	2516	2505	56.5	2480	2546	2405	2690
Sample G								
AMS	33	974	975	58.5	937	1008	842	1110
Sample H								
AMS	38	9510	9535	158.4	9474	9590	8891	9790
GPC	4	9524	9515	45	9486	9570	9485	9580
LSC	10	9352	9458	362	9130	9528	8700	9880
overall	52	9481	9523	213.2	9459	9578	8700	9880
Sample I								
AMS	37	8326	8335	66.1	8290	8366	8150	8485
GPC	5	8329	8300	53.2	8290	8383	8280	8410
LSC	7	8340	8360	106.9	8290	8391	8144	8494
overall	49	8328	8335	70.4	8290	8371	8144	8494

neonate in a waterlogged coffin that was dendro-dated to spring AD 1134 (5 timber-mean, one with bark edge). Previously, 6 consistent measurements from 4 laboratories gave a weighted mean of 934 ± 12 yr BP (A Bayliss, English Heritage, personal communication).

For Sample I (whale bone), the original laboratory entry reads: QL-1857 Jawbone of whale from sand deposits of raised beach at Svenskoya, Svalbard, Spitsbergen, Norway, dated 7950 ± 120 yr BP. The sample was isolated in permafrost with dates 8120 ± 170 yr BP above and 8350 ± 100 yr BP below. The additional result in the records for QL-1857 is 8335 ± 25 yr BP. The age was calculated at 8332.5 +24.0/−23.9 and the $\delta^{13}C$ used was −16.629‰. Sample H (whale bone) had been previously dated in Trondheim: T-13250, with a result of 9565 ± 130 yr BP, $\delta^{13}C$: −16.8‰. It seems clear that for samples I and H, these new results are (after gross outlier omission) in good agreement with the earlier measurements. For Sample G, the VIRI results appear to show a difference between the mean, the median, and the previous weighted average. There is no apparent explanation for this difference.

CONSENSUS VALUES

As in previous studies, consensus values for the samples have been calculated following the procedure in Scott (2003). Most importantly, individual results are excluded from the final calculation based on two criteria: 1) their absolute value; 2) the size of the quoted error. The consensus values are then calculated as a weighted average of the remaining results and these are reported in Table 7.

Table 7 Consensus values for VIRI Phase 2 samples.

Sample	Nr of results used	Consensus value	Error (1 σ)
E	28	39,305	121
F	44	2513	5
G	31	969	5
H	41	9528	7
I	47	8331	6

CONCLUSIONS

The preliminary analysis of results from Phase 2 of VIRI has highlighted again the general and broad agreement amongst laboratories but underlines the persistent problem with outlying data values from a relatively small number of laboratories. As mentioned earlier, no corrections have been made to the results (e.g. where a fractionation correction has not been applied), nor have we, so far, as in the past, explored the reason(s) for these outlying values. Although bone is a less commonly dated material, reflected in the smaller number of participants, the scatter of results is broadly comparable to that observed in earlier intercomparisons for other materials of roughly similar age (e.g. samples B and D in Phase 1). Given the interest in pretreatment effects, we looked at this factor and observed no statistically significant difference between methods, although a relatively small number of laboratories used methods other than Longin (1971).

The same demographic shift to more AMS and fewer radiometric laboratories is apparent from the list of participating laboratories. Overall, the number of participating laboratories is slightly lower than in Phase 1, but still represent a very healthy participation rate.

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