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SECTION 6: KAURI WOOD, SAMPLES A AND B

6.1 INTRODUCTION

Kauri wood, a sub-fossil wood from New Zealand (which had previously been used in an IAEA exercise, IAEA-C4, in 1990), was considered to be an important sample to include in FIRI because it provided a link to previous exercises, was available in sufficient quantity, and was a "close to background" organic sample. IAEA-C4 had previously been criticized since it was believed that in its milling, some contamination had been introduced, so that a replacement sample would prove useful. The Kauri wood has a very low ^{14}C activity and, as such, is very sensitive to even small amounts of contaminant carbon. Such low-activity samples give a true test for the laboratory procedures since pretreatment and laboratory background definition become critical.

In 1994, a further Kauri wood sample was used in a small intercomparison (Hogg et al. 1995) as a potential replacement for C4. This new Kauri sample was tested in 6 laboratories and a preliminary range was quoted by the authors.

6.1.1 Preliminary Testing Results

From the earlier work on this sample (Hogg et al. 1995) involving 6 laboratories, the authors concluded:

- It was not possible to assign a definitive pMC value to the sample and the authors suggested a range of 0.12–0.21 pMC.
- The results showed some evidence of in-homogeneity (probable causes being incorrect background assessment or inadequate sample pretreatment).

Nonetheless, it was decided that this new Kauri sample should be included in FIRI, and that it should be provided in duplicate, without pretreatment.

6.2 PRELIMINARY RESULTS

A total of 83 laboratories returned results within the deadline. Due to some laboratories using more than one preparation or measurement system, this gave a set of over 90 results. It is worth noting the following:

- The basic results for the Kauri samples (A and B) were often given in 2 forms, age and pMC;
- The errors (particularly for age) were asymmetrical;
- There was a substantial number of censored observations (observations reported as "greater than");
- Some results were simply given as "background."

Thus, it is apparent that there is an important variation in how the results are reported.

6.2.1 Preliminary Analysis

The preliminary analysis focused on the distribution of results, the identification of any gross outliers (using simple graphical means such as boxplots), and the calculation of preliminary consensus values based on robust statistics (medians and interquartile ranges).

In this section, the 2 independently measured duplicate samples are reported separately and then the combined results are analyzed. Finally, a comparison of the results for AMS, GPC, and LSC laboratories is reported.

6.2.2 Sample A

Ninety-eight age results were quoted, 64 of which were finite, while 5 were simply quoted as background. For pMC, 67 finite results were quoted (not all laboratories quoted both age and pMC, and for the preliminary analysis, no conversion calculations were performed, although this was done later), and 2 laboratories simply quoted the result as background. The results came from 32 AMS, 20 GPC, and 44 LSC systems. Summary information on the results reported is shown in Table 6.1 below.

Table 6.1 Summary of the reporting format for Kauri A

a) Age				b) pMC			
Reporting format	AMS	GPC	LSC	Reporting format	AMS	GPC	LSC
>	9	7	9	<	3	2	1
Background	0	1	4	Background	0	1	1
Finite	23	12	29	Finite	27	14	26

6.2.2.1 Distribution of Results

Figure 6.1 shows a boxplot with the censored (>) observations distinguished from the finite (uncensored) results.

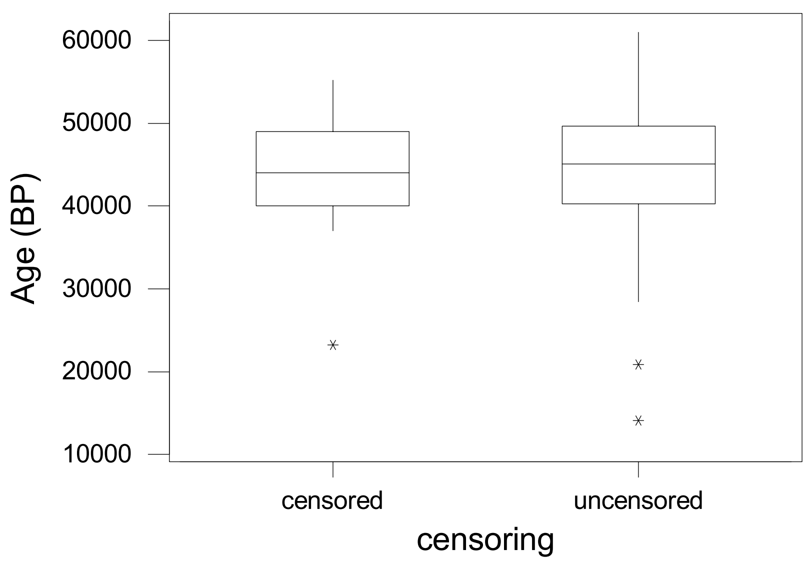

Figure 6.1 Age distribution for Kauri A

There appears to be little difference in location (activity distribution) for the censored and uncensored results. The boxplots also permit a preliminary identification of gross outliers, represented by asterisks in the figure above. Three obvious outliers with ages less than 22,000 BP are apparent.

In pMC, 3 outliers were immediately apparent with values of 7.43, 10.62, and 17.31. Figure 6.2 shows the boxplot of pMC after their removal.

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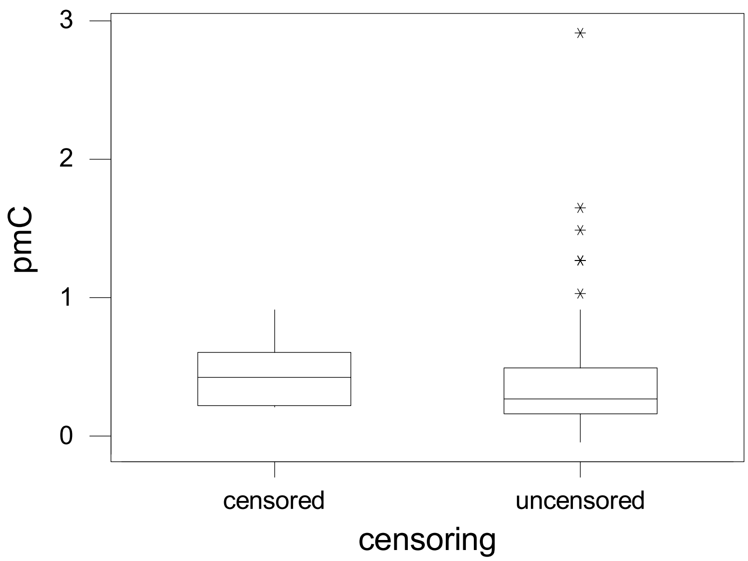

Figure 6.2 pMC distribution for Kauri A (outliers 7.43, 10.62, and 17.31 removed)

6.2.2.2 Summary Statistics (Omitting Outliers)

For finite ages, the overall mean is 44,482 yr, the median is 45,200 yr, and standard error of the mean (Semean) is 885 yr. The results for the 3 laboratory types are shown in Table 6.2 below.

Table 6.2 Summary ages for Kauri A by laboratory type

Laboratory type	Mean	Median	Semean
AMS	48,180	49,200	897
GPC	46,534	46,468	2196
LSC	40,565	41,140	1270

There are statistically significant differences in the means between LSC and both AMS and GPC laboratories.

For pMC, the overall mean is 0.4181, the median is 0.2705, and standard error of the mean is 0.0582.

Table 6.3 Summary results for pMC for Kauri A by laboratory type

Laboratory type	Mean	Median	Semean
AMS	0.2741	0.2	0.0504
GPC	0.3094	0.25	0.0636
LSC	0.653	0.45	0.135

There is a statistically significant difference in the average pMC between LSC and AMS laboratories.

6.2.3 Duplicate B

Ninety-nine age results were returned, 57 of which were finite and 7 simply quoted as background. For pMC, 64 results were finite and 2 were quoted as background. Results were received from 33 AMS, 21 GPC, and 45 LSC systems.

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Table 6.4 Summary of reporting format for Kauri B

a) Age				b) pMC			
Reporting format	AMS	GPC	LSC	Reporting format	AMS	GPC	LSC
>	11	10	10	<	5	2	2
Background	0	2	5	Background	0	1	1
Finite	22	9	26	Finite	26	15	23

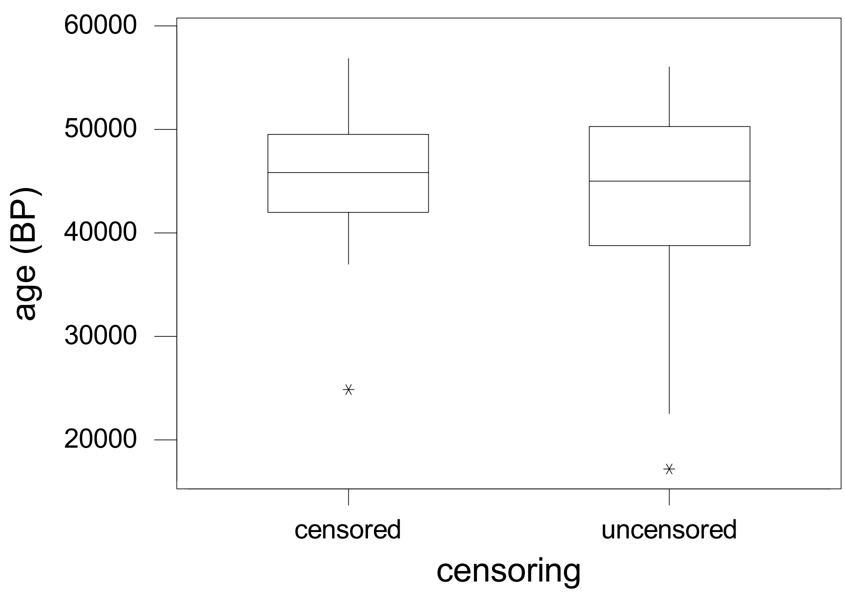

Figure 6.3 Age distribution for Kauri B

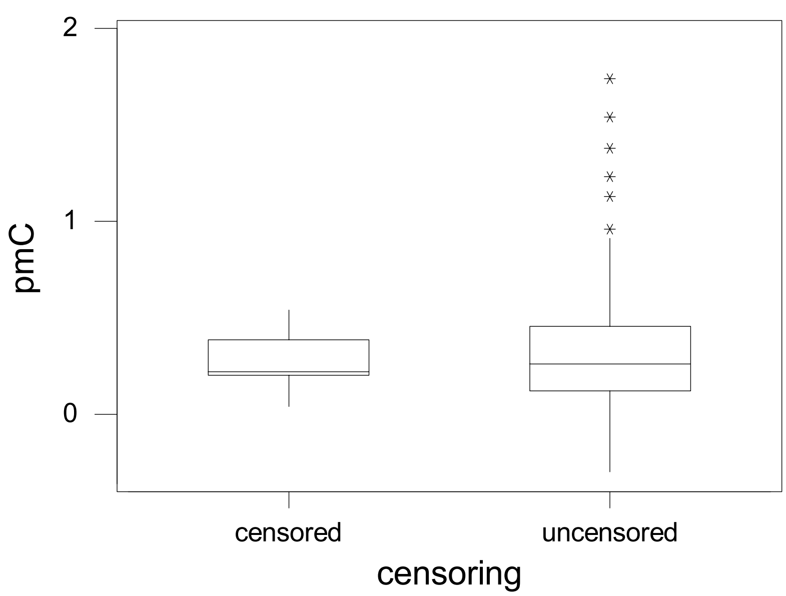

Figure 6.4 pMC distribution for Kauri B (outliers 4.86 and 8.41 removed)

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6.2.3.1 Distribution of Results

Figures 6.3 and 6.4 show the boxplots with the censored and uncensored observations for age and pMC. A preliminary identification of gross outliers indicates 2 outliers with ages less than 22,000 BP and in pMC, 2 outliers were identified with values of 4.86 and 8.41.

For finite ages, the overall mean is 43,699 yr, the median is 45,000 yr, and the standard error of the mean is 1086 yr.

Table 6.5 Summary ages for Kauri B (with outliers removed)

	Mean	Median	Semean
AMS	48,942	49,350	1034
GPC	40,832	42,231	3681
LSC	40,254	41,007	1419

Statistically significant differences in age were observed between AMS and both LSC and GPC laboratories.

For pMC, the overall mean is 0.38, with a median of 0.26, and a standard error of the mean of 0.05.

Table 6.6 Summary pMC for Kauri B (with outliers removed)

	Mean	Median	Semean
AMS	0.2373	0.1750	0.037
GPC	0.348	0.237	0.122
LSC	0.5888	0.44	0.096

A statistically significant difference between LSC and AMS results was observed. Again, it is clear that the median tends to be older than the mean. Other extreme observations are also highlighted.

6.2.4 Combined Results

Since the samples were duplicates (each being split from a single block of 100 g), the results can be combined.

For age, 197 results in total were returned, 120 of which were finite and 12 simply quoted as background. For pMC, there were 125 finite results and 4 quoted as background. Overall, there were 65 AMS, 39 GPC, and 93 LSC measurements.

Table 6.7 Summary of reporting format for Kauri A and B

a) Age				b) pMC			
Reporting format	AMS	GPC	LSC	Reporting format	AMS	GPC	LSC
>	21	17	19	<	9	4	16
Background	0	3	9	Background	0	2	4
Finite	44	19	57	Finite	52	29	44

6.2.4.1 Distribution of Results

Figures 6.5 and 6.6 show the boxplots with the censored and uncensored observations marked separately for age and pMC. A preliminary identification shows 2 clear age outliers with ages of 14,090 and 17,180 BP.

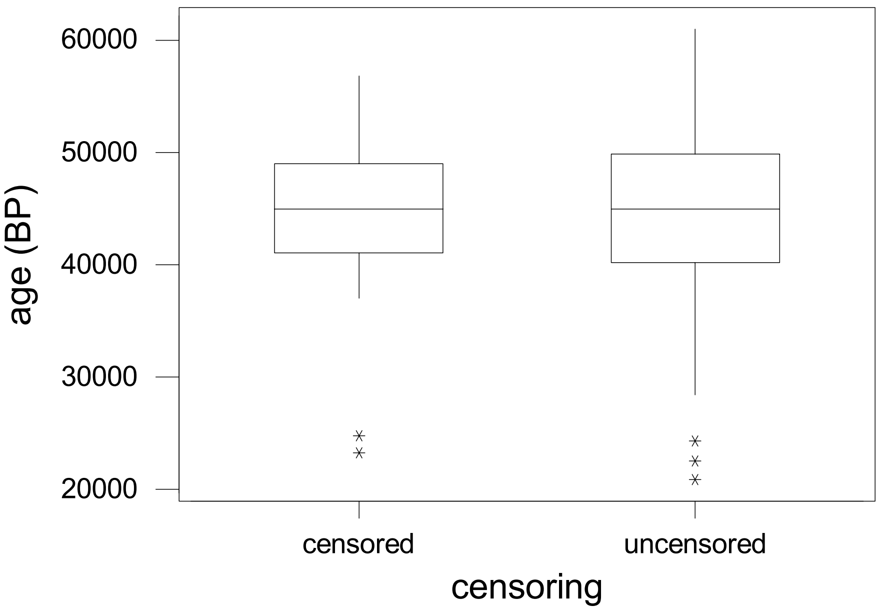

Figure 6.5 Age distribution for Kauri A and B (outliers 14,090 and 17,180 removed)

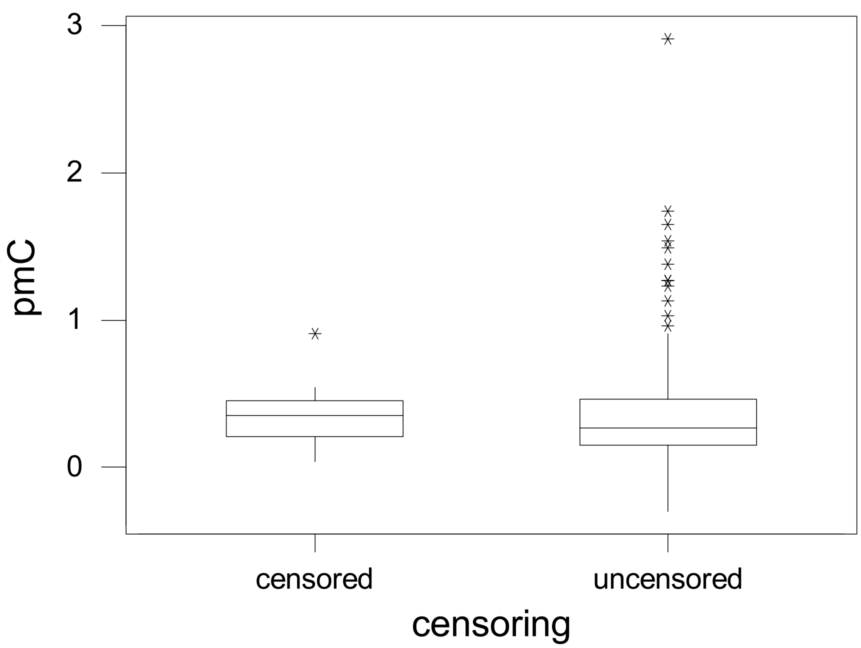

Figure 6.6 pMC distribution for Kauri A and B (outliers 4.86, 8.41, 7.43, 10.62, and 17.31 removed)

For pMC, 5 clear outliers were identified with values of 4.86, 8.41, 7.43, 10.62, and 17.31.

For finite ages, the overall mean is 44,336 BP, with a median of 45,000 BP, and a standard error of the mean of 660 yr.

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Table 6.8a Summary results for Kauri A and B age (yr BP) by laboratory type

	Mean	Median	Semean
AMS	48,552	49,200	677
GPC	44,617	44,043	1495
LSC	40,789	41,013	996

A statistically significant difference between LSC and AMS results was observed.

Table 6.8b Summary results for Kauri A and B (pMC) by laboratory type

	Mean	Median	Semean
AMS	0.2561	0.19	0.0313
GPC	0.3292	0.24	0.0691
LSC	0.6225	0.445	0.0831

The overall mean pMC is 0.40, with a median of 0.26, and a standard error of the mean of 0.038.

A statistically significant difference between mean pMC for LSC and AMS systems and LSC and GPC systems was observed.

6.3 CONCLUSIONS BASED ON THE PRELIMINARY ANALYSIS

For all Kauri sample results, a preliminary analysis gives a median pMC value of 0.24 and interquartile range (IQR) of 0.15–0.44. The mean is noticeably higher (0.38) since it is non-robust and affected by extreme values. The results are also higher than those quoted by Hogg et al. (1995), but are based on a much wider group of laboratories. This analysis has only excluded the most extreme outliers. However, there is clearly some considerable variation in the results, which may be a function of laboratory background (estimation and material used) and the limits of detection. Interestingly, the analysis also appears to indicate some differences in the distribution of results between laboratory types, with AMS laboratories quoting older ages in general.

6.4 ANALYSIS OF ACTIVITY, A AND B SEPARATELY

Analysis for Kauri A and B should, in principle, follow a similar approach to that for Samples C–J, but this must be modified when considering the age of the sample and the issue of finite age reporting. By this we mean that for age, many results were simply quoted as "greater than" or indeed as "background" (described as "censored"). However, the analysis of the pMC results (since the majority of results are given in a finite form) will follow a similar pattern to the analysis for the other samples. Following the exploratory analysis, outliers have been omitted.

First, we investigate the association, if any, between whether a measurement is censored and other laboratory factors.

6.4.1 Association Between Censoring and Laboratory Factors

6.4.1.1 Kauri A

Table 6.9a Reporting status by laboratory type

	AMS	GPC	LSC	**All**
Censored	3	3	3	**9**
Uncensored	28	14	28	**70**
All	31	17	31	**79**

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No evidence of an association is found; thus, one laboratory type is no more likely to report censored results than any other.

Table 6.9b Reporting status by modern standard used

	ASUC	Benz	NBS1	NBS12	NBS2	Other	**All**
Censored	1	0	2	1	3	2	**9**
Uncensored	5	4	21	5	25	6	**66**
All	6	4	23	6	28	8	**75**

Although not able to complete a formal statistical test due to the small numbers in some cells, there is no strong evidence of a statistically significant association between the reporting status and the modern standard.

Table 6.9c Reporting status by background material used

	Anth	Benz	Calc	Charc	Coal	Graph	Marble	Other
Censored	0	2	0	1	0	0	2	3
Uncensored	16	13	1	1	8	8	5	11
All	16	15	1	2	8	8	7	14

Although not able to complete a formal test, there is no strong evidence of a statistically significant association between the reporting status and the background material.

6.4.1.2 Kauri B

Table 6.10a Reporting status by laboratory type

	AMS	GPC	LSC	**All**
Censored	5	3	4	**12**
Uncensored	27	14	22	**63**
All	32	17	26	**75**

There is no statistically significant association between the laboratory type and the censoring mechanism.

Table 6.10b Reporting status by modern standard

	ASUC	Benz	NBS1	NBS12	NBS2	Other	**All**
Censored	1	0	4	1	4	2	**12**
Uncensored	5	2	18	6	23	4	**58**
All	6	2	22	7	27	6	**70**

There is no statistically significant association between the modern standard and the censoring mechanism.

Table 6.10c Reporting status by background

	Anth	Benz	Calc	Charc	Coal	Graph	Marble	Other
Censored	0	2	0	1	1	0	2	5
Uncensored	15	8	1	1	8	8	4	10
All	15	10	1	2	9	8	6	15

6.4.1.3 Conclusions

In all cases, no statistically significant association was found; thus, there is no evidence that one type of laboratory, modern standard material, or background material, is linked to whether the result is censored.

6.5 ANALYSIS OF ACTIVITY: SOURCES OF VARIATION

In this section, we now consider the effect of laboratory type, modern standard, and background material on pMC (for the purposes of this analysis, we ignore the 6 censored values and treat them as uncensored). Figure 6.7 shows the distribution of results by the 3 factors. Some variation in the results is apparent.

6.5.1 Kauri A

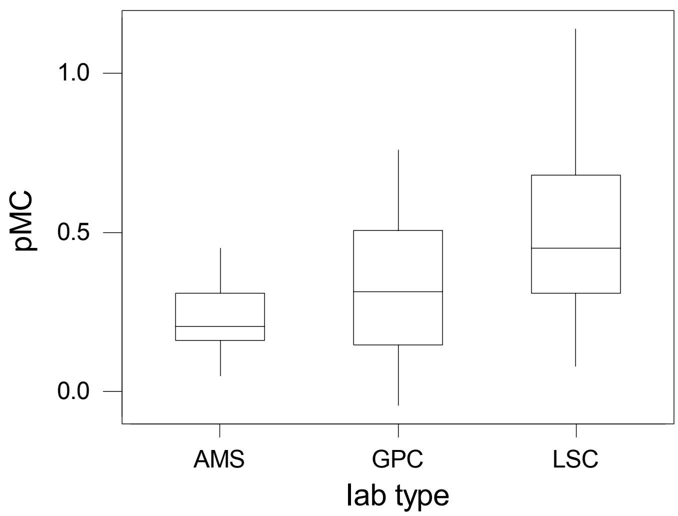

Figure 6.7a Distribution by laboratory type

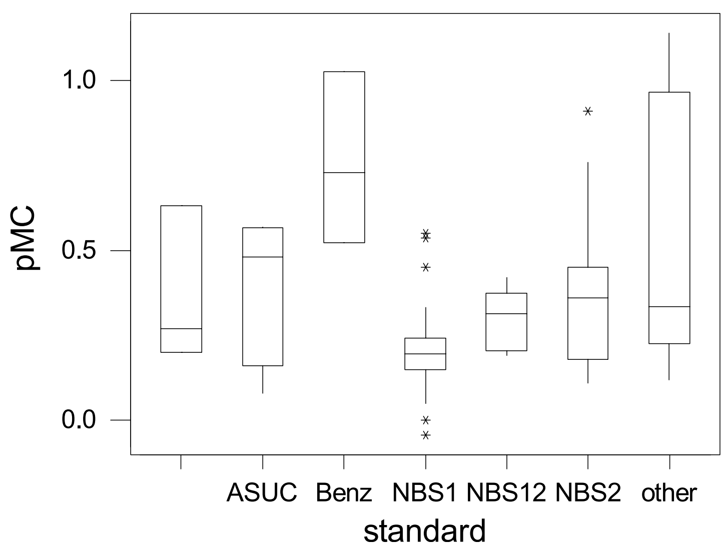

Figure 6.7b Distribution by modern standard

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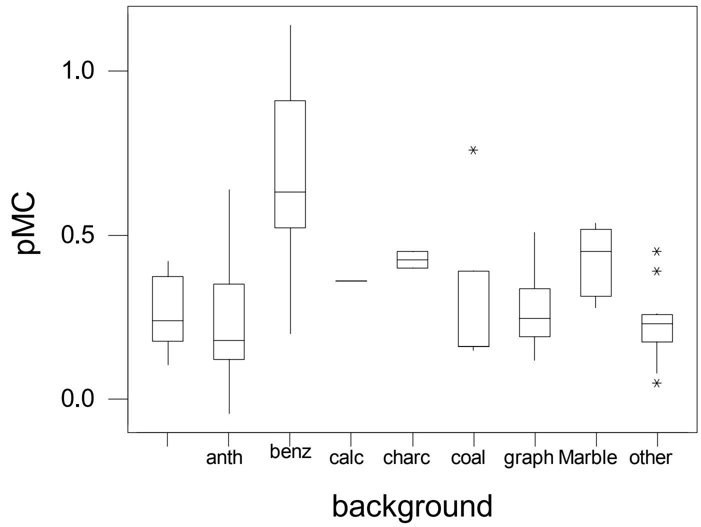

Figure 6.7c Distribution by background material

6.5.1.2 Formal Analysis

The formal analysis for each factor takes into account the hypothesis that there is no difference in the mean pMC due to the different levels of the laboratory factors. The results are shown in Table 6.11.

Table 6.11a Effect of laboratory type

```
Source       DF        SS        MS         F        P
type          2    0.9316    0.4658     10.52    0.000
Error        64    2.8328    0.0443
Total        66    3.7645
                                    Individual 95% CIs For Mean
                                    Based on Pooled StDev
Level         N      Mean     StDev  -------+---------+---------+---------
AMS          30    0.2358    0.0999  (------*-----)
GPC          16    0.3301    0.2287        (--------*-------)
LSC          21    0.5098    0.2966                        (------*-------)
                                     -------+---------+---------+---------
Pooled StDev =     0.2104                 0.24      0.36      0.48
```

Table 6.11b Effect of modern standard

```
Source       DF        SS        MS         F        P
standard      5    1.0910    0.2182      4.94    0.001
Error        58    2.5637    0.0442
Total        63    3.6547
                                    Individual 95% CIs For Mean
                                    Based on Pooled StDev
Level         N      Mean     StDev  -----+---------+---------+---------+-
ASUC          4    0.4025    0.2287     (-------*--------)
Benz          3    0.7597    0.2538                 (---------*---------)
NBS1         22    0.2163    0.1478  (---*--)
NBS12         6    0.3017    0.0906  (------*------)
NBS2         23    0.3653    0.2070        (---*--)
other         6    0.5167    0.4086           (------*------)
                                     -----+---------+---------+---------+-
Pooled StDev =     0.2102               0.25      0.50      0.75      1.00
```

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Table 6.11c Effect of background material

```
Source      DF       SS       MS        F        P
background   7   1.7494   0.2499     6.96    0.000
Error       53   1.9029   0.0359
Total       60   3.6523
                                   Individual 95% CIs For Mean
                                   Based on Pooled StDev
Level        N     Mean    StDev  -+---------+---------+---------+-----
anth        15   0.2359   0.1904         (--*---)
benz        11   0.6902   0.2836                          (----*---)
calc         1   0.3600   0.0000   (--------------*---------------)
charc        2   0.4250   0.0354         (----------*----------)
coal         7   0.3071   0.2257          (----*-----)
graph        8   0.2689   0.1211        (-----*----)
Marble       5   0.4234   0.1066             (------*------)
other       12   0.2283   0.1114        (---*----)
                                  -+---------+---------+---------+-----
Pooled StDev =   0.1895           0.00      0.25      0.50      0.75
```

6.5.1.3 Conclusions

A significant laboratory type effect is observed, with AMS laboratories having lower mean quoted pMC. Similarly, a significant modern standard effect is observed, with NBS1 giving the lowest mean pMC. There is also a statistically significant effect of the background material with apparent differences between laboratory results based on anthracite or benzene as the background material.

In all cases for Kauri A, laboratory type (LSC laboratories have, on average, higher pMC than AMS or GPC), modern standard, and background material were all found to be statistically significant.

6.5.2 Kauri B

The same analysis is repeated for Kauri B and results presented in the same format. Figure 6.8 shows the considerable variation in the distribution of results over the factor levels.

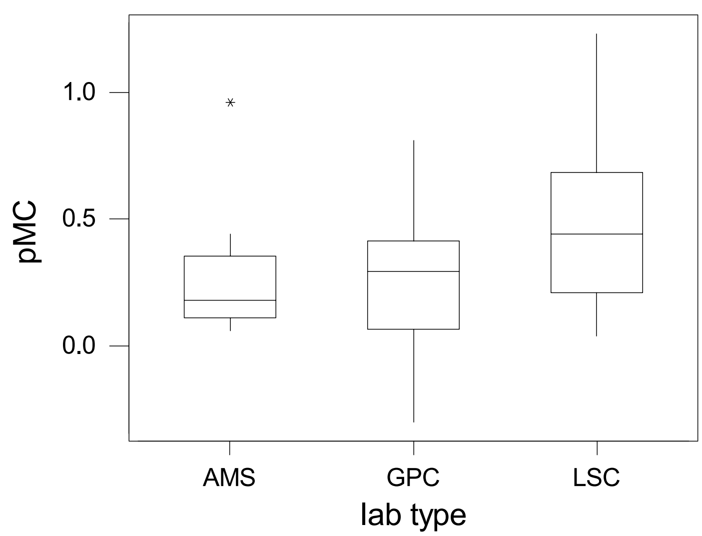

Figure 6.8a Distribution by laboratory type

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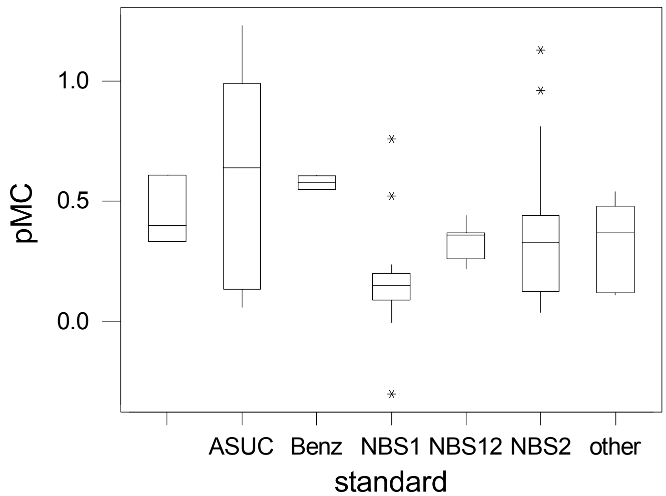

Figure 6.8b Distribution by modern standard

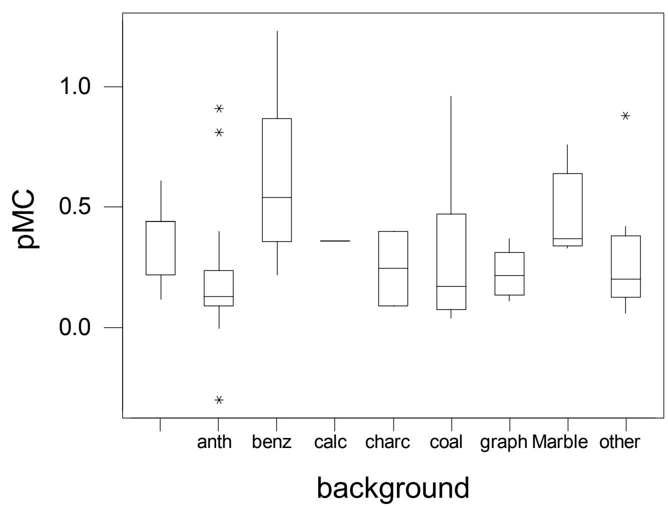

Figure 6.8c Distribution by background material

6.5.2.1 Formal Analysis

Table 6.12 shows the results of the formal analysis.

Table 6.12a Effect of laboratory type

Source	DF	SS	MS	F	P
Type	2	0.9957	0.4978	7.88	0.001
Error	66	4.1679	0.0631		
Total	68	5.1636			

Level	N	Mean	StDev	Individual 95% CIs For Mean Based on Pooled StDev
				-+---------+---------+---------+-----
AMS	32	0.2344	0.1744	(-----*-----)
GPC	16	0.2623	0.2681	(-------*--------)
LSC	21	0.5037	0.3276	(-------*------)
				-+---------+---------+---------+-----
Pooled StDev =		0.2513		0.15 0.30 0.45 0.60

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Table 6.12b Effect of modern standard

```
Source     DF        SS        MS        F        P
standard    5    1.1579    0.2316     3.55    0.007
Error      60    3.9150    0.0652
Total      65    5.0729
                                  Individual 95% CIs For Mean
                                  Based on Pooled StDev
Level       N      Mean     StDev  --------+---------+---------+--------
ASUC        6    0.6067    0.4683                (-------*--------)
Benz        2    0.5780    0.0396         (-------------*--------------)
NBS1       21    0.1646    0.1974  (----*---)
NBS12       7    0.3357    0.0741      (------*-------)
NBS2       25    0.3504    0.2787          (---*---)
other       5    0.3140    0.1877   (---------*--------)
                                   --------+---------+---------+--------
Pooled StDev =   0.2554                  0.25      0.50      0.75
```

Table 6.12c Effect of background material

```
Source     DF        SS        MS        F        P
background  7    1.1787    0.1684     2.39    0.033
Error      54    3.8000    0.0704
Total      61    4.9787
                                  Individual 95% CIs For Mean
                                  Based on Pooled StDev
Level       N      Mean     StDev  ------+---------+---------+---------+
anth       15    0.2123    0.3019          (---*----)
benz        9    0.6099    0.3459                     (-----*-----)
calc        1    0.3600    0.0000  (-----------------*-----------------)
charc       2    0.2450    0.2192    (-----------*------------)
coal        9    0.2822    0.3064          (-----*-----)
graph       8    0.2226    0.0967        (-----*------)
Marble      5    0.4662    0.1807                (-------*------)
other      13    0.2638    0.2183           (----*----)
                                   ------+---------+---------+---------+
Pooled StDev =   0.2653                0.00      0.30      0.60      0.90
```

6.5.2.2 Conclusions

In all cases for Sample B, we have evidence of a statistically significant effect due to laboratory type, modern standard, and background material used. Again, there are apparent differences:

- ANU sucrose results give the highest average pMC;
- There is a difference in the average pMC for anthracite and benzene;
- LSC laboratories quote, on average, higher pMC values.

6.6 ANALYSIS OF AGE, KAURI A

We now use the techniques developed in the reliability analysis (see Appendix 3) to explore the age distribution, which, therefore, means that we must utilize both censored and uncensored values. A censored datum is one for which the result is expressed as "> age" BP.

In addition, given the censored nature of the data, non-parametric methods of estimation, used commonly in survival or reliability analyses (in particular, the Kaplan-Meier survival estimator), have been used to estimate the "mean" activity of the sample. Reliability plots display the "survival" probabilities versus time, which in this context, is the probability that the sample is greater than age *t*. Each point on the plot represents the proportion of results greater than age *t* and the non-parametric reliability curve is shown graphically as a step function. In addition, common measures of the center and spread of the distribution of age are estimated. It should be noted that the mean is very sensitive to large ages, while the median, Q1 (25th percentile), Q3 (75th percentile), and interquartile range (IQR) are resistant, so they are quoted in preference.

The outlier definitions used are identical to those used in the pMC analysis.

6.6.1 Kauri A

There were 25 censored and 58 uncensored ages. Table 6.13 shows the mean and median age (estimated taking the censoring into account), the quartiles, the interquartile range, and a 95% confidence interval (CI) for the true mean age.

Table 6.13 Age of Kauri A

						95.0% normal CI	
Mean	Median	Q1	Q3	IQR	Standard error	Lower	Upper
47,007	47,935	43,900	51,530	7630	808	45,423	48,590

The mean age is estimated at 47,006 BP, with a 95% CI of 45,423–48,590 BP. The median is approximately 1000 yr older than the mean age, suggesting a tail of younger results. The 95% CI spans almost 4000 yr, indicating the substantial variation in the reported results.

6.6.2 Sources of Variation

If we now consider a similar analysis for each of the factors (laboratory type, modern standard, and background material), we can explore the differences in the age distribution of the results that also account for censoring.

For LSC laboratories, there were 26 values, 8 of which were censored; for GPC, there were 17 results, 7 of which were censored values; while for AMS, there were 32 results, 10 of which were censored.

Table 6.14 Age estimation by laboratory type

							95.0% normal CI	
	Mean	Median	Q1	Q3	IQR	Standard error	Lower	Upper
LSC	44,155	44,024	40,190	47,600	7410	1641	40,939	47,372
GPC	47,507	47,935	42,440	52,240	9800	1477	44,610	50,403
AMS	49,408	50,200	47,490	51,530	4040	569	48,293	50,524

It is clear from Table 6.14 that the AMS laboratories report a significantly older mean age for this sample (median = 50,200 yr BP) than either LSC or GPC laboratories.

6.6.2.1 Comparison of Age Distributions

A formal test comparing the age distribution can be carried out and has a p-value <0.05, showing quite clearly that there is a significant difference in the age distribution for the 3 laboratory types. Figure 6.9 shows the cumulative age distribution for the 3 laboratory types. This shows that the GPC

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and AMS curves lie clearly above that for LSC. GPC and AMS laboratories are typically measuring and quoting older ages for this sample.

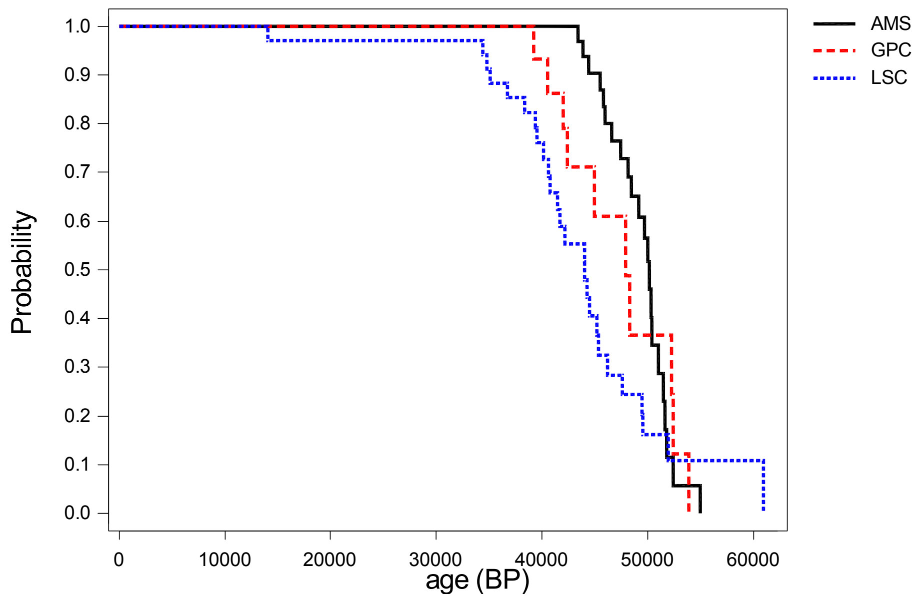

Figure 6.9 Cumulative age distribution by laboratory type

6.6.3 By Standard Material

The analysis used previously for the modern standard material is used again and shows a significant difference in the age distribution. Table 6.15 and Figure 6.10 show the age distributions.

Table 6.15 Age estimation by modern standard[a]

							95.0% normal CI	
	Mean	Median	Q1	Q3	IQR	Standard error	Lower	Upper
Other	44,800	46,610	45,000	47,935	2935	2258	40,374	49,225
NBS2	45,995	45,398	44,024	51,971	7947	1639	42,782	49,208
NBS12	48,233	50,300	45,500	50,300	4800	1436	45,417	51,049
NBS1	49,399	50,200	48,305	51,800	3495	731	47,966	50,832
Benz	40,585	39,556	36,780	42,211	5431	2574	35,539	45,631
Sucrose	40,425	*	*	*	*	1374	37,730	43,119

[a] * indicates that there were insufficient data to complete the calculation

6.6.3.1 Comparison of Survival Curves

The summary statistics of the age for each standard type are shown in the following.

The formal test of comparability of the cumulative age distribution results in p-values <0.05, so we can conclude that there is a statistically significant difference in the age distributions for the different modern standards. Figure 6.10 shows that the benzene curve is lower than all others and suggests that the NBS1 curve is the highest. This would suggest that laboratories using benzene as

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their modern standard are quoting younger ages than laboratories using other modern standard materials.

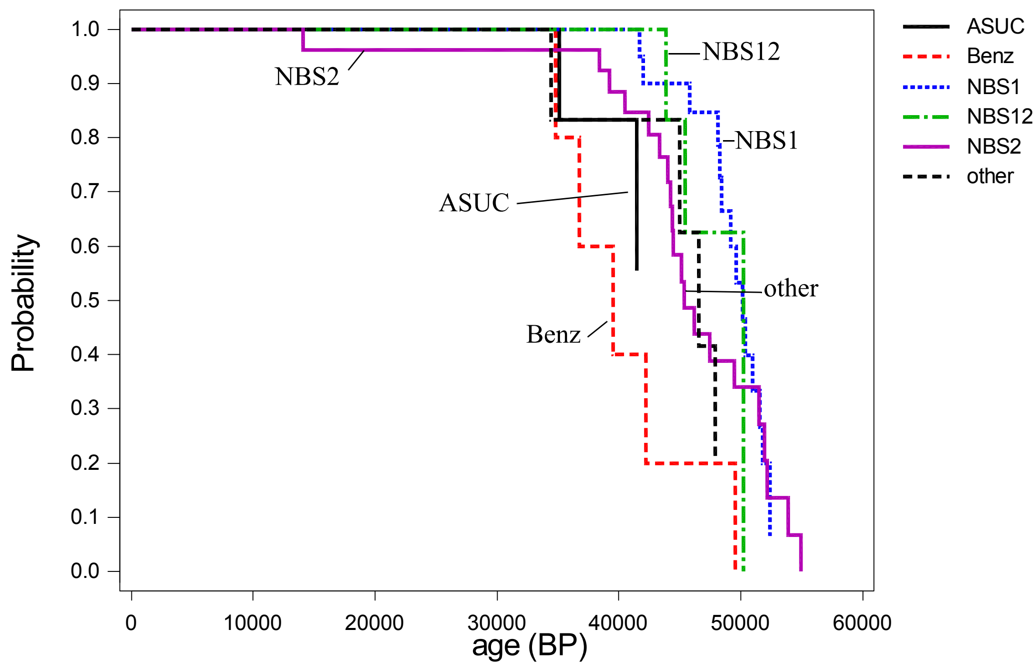

Figure 6.10 Cumulative age distribution by modern standard

6.6.4 Age Distribution by Background Material

Table 6.16 and Figure 6.11 repeat a similar analysis, but take into account the background material used.

Table 6.16 Age estimation by background material[a]

	Mean	Median	Q1	Q3	IQR	Standard error	95.0% normal CI	
							Lower	Upper
Other	47,051	48,305	44,400	50,380	5980	1260	44,581	49,522
Marble	41,988	*	—	—	—	—	*	—
Graphite	47,748	47,490	45,500	50,200	4700	1005	45,777	49,720
Coal	48,014	51,530	44,480	51,800	7320	1936	44,219	51,809
Charc	43,390	*	—	—	—	*	*	—
Anthracite	48,203	52,240	45,818	53,900	8082	2574	43,156	53,249

[a] * indicates that there were insufficient data to complete the calculation

The formal test again showed a significant difference in the age distribution between the different background materials (as evidenced in Figure 6.11). The results for laboratories using benzene as a background material lie below the curves for other background materials, so the reported ages tend to be younger for those laboratories using benzene as a background material (LSC laboratories) and this is confirmed in Table 6.16.

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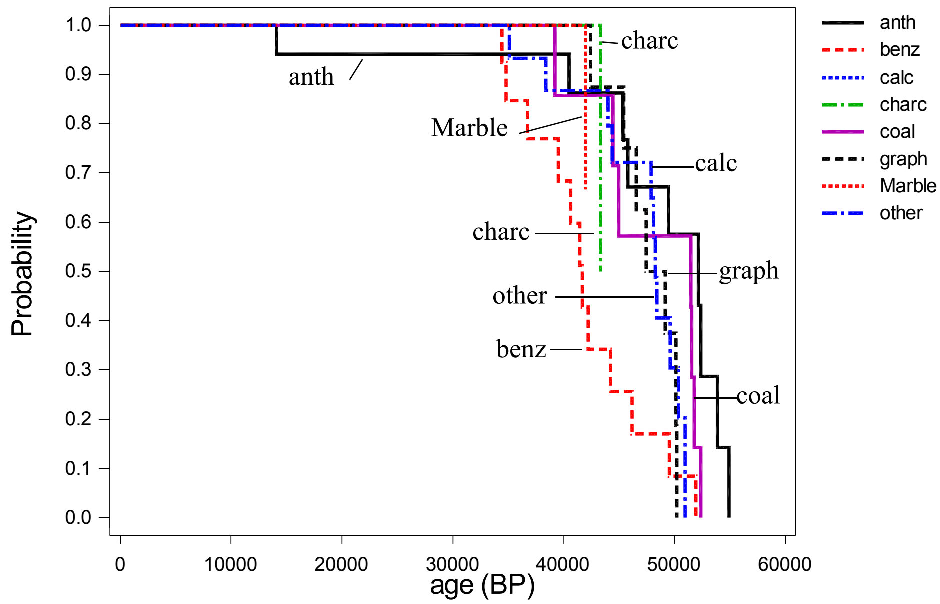

Figure 6.11 Cumulative age distribution by background material

6.7 ANALYSIS OF AGE, KAURI B

For Kauri B, a total of 83 measurements were reported, 51 of which were uncensored. The summary of the age distribution is given in the table below.

Table 6.17 Age estimation

						95.0% normal CI	
Mean	Median	Q1	Q3	IQR	Standard error	Lower	Upper
48,210	49,815	44,043	53,393	9350	730	46,779	49,641

The mean age is 48,210 BP, with the median age being approximately 1000 yr older, again suggesting that the distribution of ages has a long left tail (younger results). The IQR of just over 9300 yr again shows the considerable variation in the results reported.

6.7.1 Analysis by Laboratory Type

The formal test of equal cumulative distributions shows a significant difference in age for the different laboratory types (as shown in Table 6.18 and Figure 6.12). For LSC, 10 of 32 measurements were censored, GPC had 10 censored from 17 measurements, and AMS had 12 censored from 34 measurements. Again, we see in the figure that the LSC distribution lies clearly below the GPC and AMS distributions.

Table 6.18 Age distribution for laboratory type

							95.0% normal CI	
	Mean	Median	Q1	Q3	IQR	Standard error	Lower	Upper
LSC	44,423	44,900	39,200	49,900	10,700	999	42,643	46,382
AMS	50,612	51,000	46,660	54,500	7840	878	48,890	52,333
GPC	53,140	53,140	44,043	53,393	9350	1661	45,681	53,393

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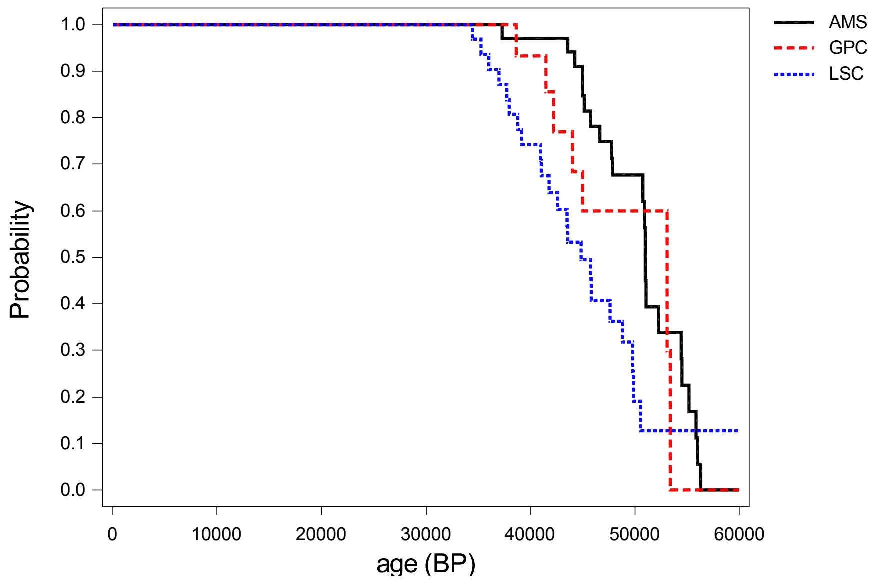

Figure 6.12 Cumulative age distribution by laboratory type

6.7.3 Age Distribution by Modern Standard

Figure 6.13 and Table 6.19 show the age distributions for the laboratories using different modern standards. The formal statistical test shows a significant difference in the age distribution, with those laboratories using benzene as the modern standard quoting results that are significantly younger on average.

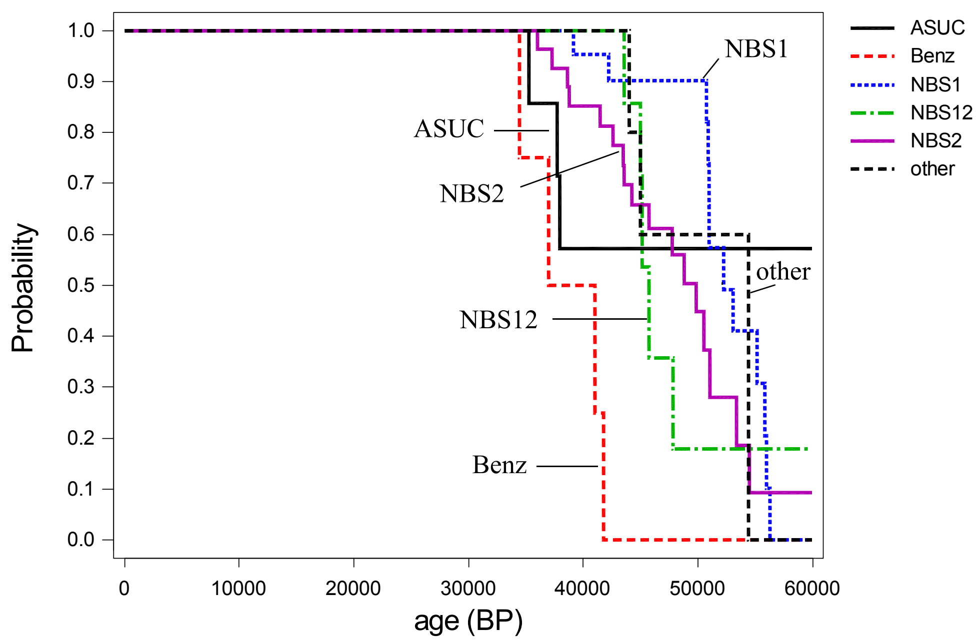

Figure 6.13 Cumulative age distribution by modern standard

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Table 6.19 Age estimation for modern standard type[a]

	Mean	Median	Q1	Q3	IQR	Standard error	95.0% normal CI Lower	Upper
Other	50,492	54,473	45,000	54,473	9473	2675	45,248	55,736
NBS2	47,766	49,900	43,540	53,393	9853	1199	45,415	50,116
NBS12	46,014	45,800	45,000	47,900	2900	686	44,668	47,360
NBS1	52,250	52,300	50,900	55,900	5000	1092	50,109	54,390
Benz	38,549	37,000	34,420	41,013	6593	1728	35,161	41,937
Sucrose	37,584	*	—	—	*	431	36,739	38,429

[a] * indicates that there were insufficient data to complete the calculation

6.7.4 Effect of Background Material

The results (Table 6.20 and Figure 6.14) again show a clear difference in the age distributions due to the background material used. The formal test shows this result is statistically significant, with laboratories using benzene and marble as their background material quoting younger ages.

Table 6.20 Age estimation by background material[a]

	Mean	Median	Q1	Q3	IQR	Standard error	95.0% normal CI Upper	Lower
Other	49,533	50,800	44,300	50,900	6600	1812	45,982	53,085
Marble	41,473	42,231	*	*	*	928	39,654	43,292
Graph	49,605	47,900	45,800	52,300	6500	1270	47,115	52,095
Coal	49,496	51,090	45,000	56,000	11,000	2387	44,816	54,176
Benz	41,919	41,764	36,030	45,830	9800	1560	38,860	44,978
Anth	51,214	53,140	50,600	54,500	3900	1639	48,000	54,428

[a] * indicates that there were insufficient data to complete the calculation

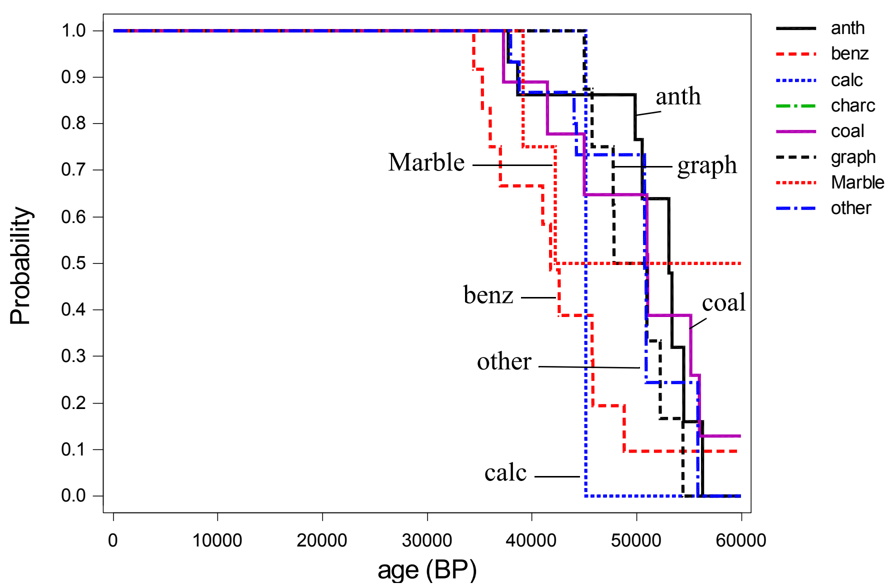

Figure 6.14 Cumulative age distribution by background material (charcoal not shown)

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6.8 ANALYSIS OF AGE, COMBINED RESULTS

In total, of the 166 measurements on A and B combined, 57 were censored. The overall results are summarized below (Table 6.21) and show a median age of 48,305 BP, and the 50% range of the data as 43,900–51,800 BP.

Table 6.21 Age estimation (A and B combined)

						95.0% normal CI	
Mean	Median	Q1	Q3	IQR	Standard error	Upper	Lower
47,634	48,305	43,900	51,800	7900	555	46,545	48,723

6.8.1 Sources of Variation

The 3 main sources of variation—laboratory type, modern standard, and background material—are analyzed in the following sections.

6.8.1.1 Effect of Laboratory Type

Again, laboratory type is found to be highly significant. From Table 6.22, the mean and median age reported by AMS laboratories is approximately 2000 and 5000 yr greater than GPC and LSC laboratories, respectively. Figure 6.15 shows the cumulative age distribution curves, with the LSC curve lying below those for AMS and GPC.

Table 6.22 Age by laboratory type

							95.0% normal CI	
	Mean	Median	Q1	Q3	IQR	Standard error	Upper	Lower
AMS	50,007	50,800	47,490	52,300	4810	533	48,961	51,054
GPC	48,097	48,305	42,440	53,140	10,700	1090	45,960	50,234
LSC	45,039	44,300	40,190	49,580	9390	1130	42,824	47,254

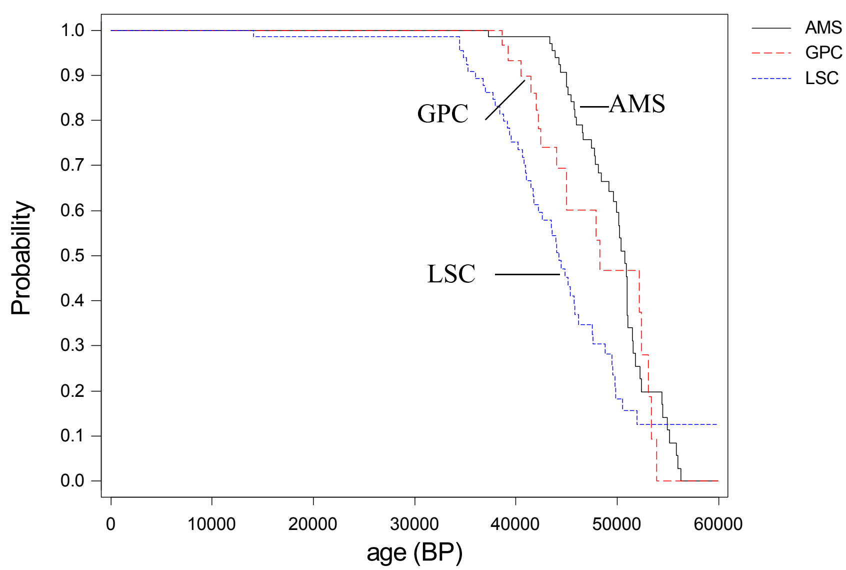

Figure 6.15 Cumulative age distribution by laboratory type

6.8.1.2 Effect of Modern Standard

A statistically significant difference in age distributions due to modern standard is found (Figure 6.16).

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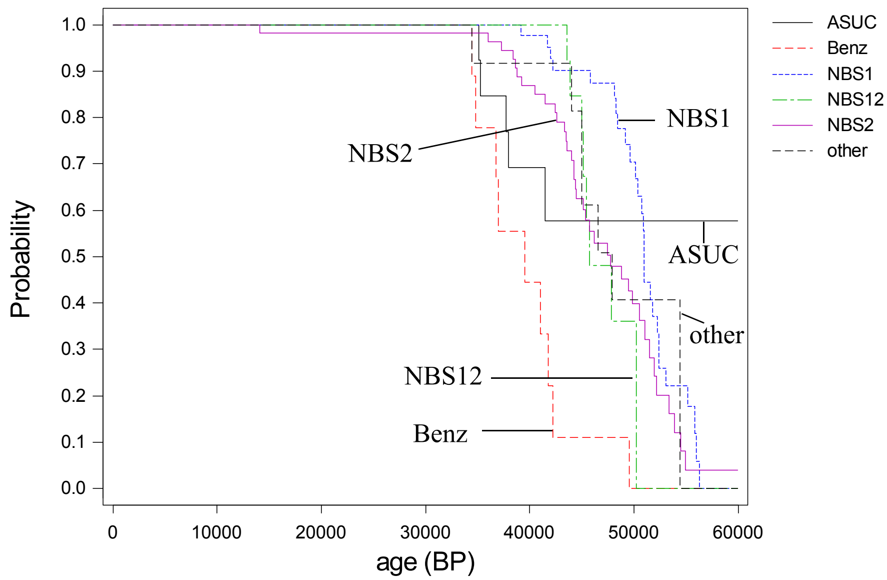

Figure 6.16 Cumulative age distribution by modern standard material

NIST OXI shows an age distribution that favors older ages, while laboratories using benzene as the modern standard quote overall younger ages, suggesting that the benzene activity is too high in comparison to the primary standards of NIST OXI and OXII.

6.8.1.3 Effect by Background Material

A statistically significant difference in the age distributions due to background material is found (Figure 6.17).

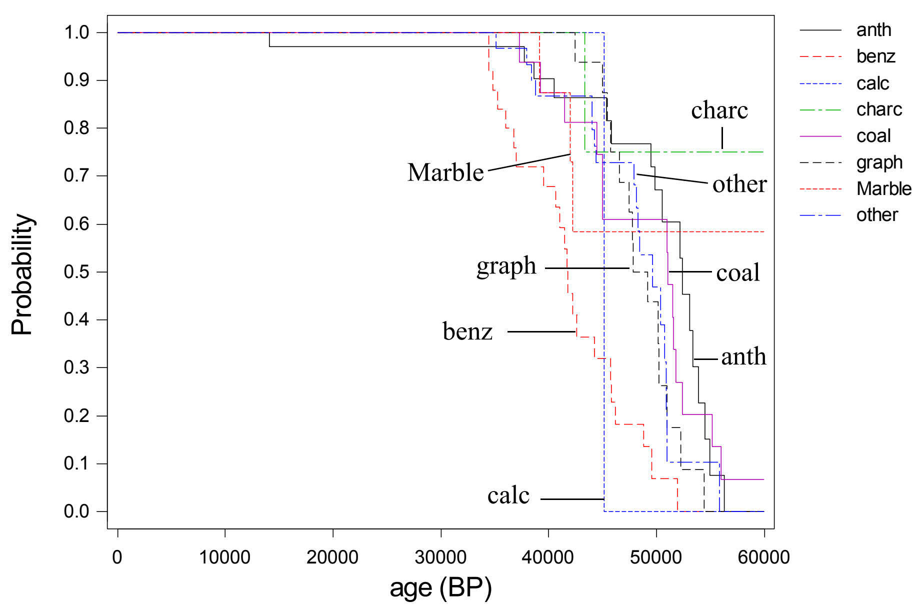

Figure 6.17 Cumulative age distribution by background material

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There is a suggestion that laboratories using benzene as the background material are quoting younger ages on average.

6.9 CONCLUSIONS

Overall, this analysis has demonstrated significant differences between the laboratory types in the age distribution quoted for this near-background sample. At the same time, the effects of the modern standard and the background material have also been identified. This most sensitive sample to the laboratory parameters has shown significant differences due to laboratory type (LSC laboratories appear to be significantly different from AMS and GPC laboratories). This finding is further supported by the findings for the effects of modern standard and background material (where the use of benzene has been identified). Further, the intercomparison has also underlined the variation in the calculation and reporting formats for near-background samples.