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SECTION 2: THE RESULTS

2.1 Distribution of Samples

The sets of core samples were distributed to over 120 laboratories that had returned an original questionnaire seeking expressions of interest in participation. A reporting format for the results was also agreed and distributed to the laboratories at the same time. This is shown in Table 2.1. Laboratories were originally given 1 yr (i.e., to August 2000) to complete the analyses and return the results, but this was later extended to December 2000. In this section, we briefly describe the laboratory characteristics and the overall response rate of the participating laboratories.

Table 2.1 The agreed reporting format

1. Contact details
Laboratory name:
Contact person:
E-mail address:
Number of analyses routinely performed per yr (please tick appropriate box):
❑ less than 100
❑ between 100 and 200
❑ between 200 and 500

2. Sample details
Material:
FIRI sample code (A–J):
Your laboratory code for the sample:

3. Measurement technique (please tick appropriate box):

AMS	GPC	LSC
❑ graphite target	❑ CO_2	❑ benzene
❑ other	❑ other	❑ other

4. Preparations Procedures
Sample pretreatment procedures (prior to carbon isotope analysis):
Mass of carbon used in the measurement:
Modern standard material used in the measurement (please tick):
❑ NBS OXI
❑ NBS OXII
❑ other
Please specify other:
Conversion factor to primary standard of activity of 1890 wood:
Background reference material used:

5. Results
5.1 $\delta^{13}C$ (‰) wrt VPBD, stating whether measured or estimated:
The $\delta^{13}C$ measurement (if measured) represents the isotopic ratio in (please tick appropriate box):
❑ the raw material
❑ the material after pretreatment
❑ the actual sample measured
5.2 Age (conventional yr BP ±1):
5.3 Percent modern (defined as: normalized sample activity/normalized standard activity expressed as a percentage.) Note: this should not be decay corrected.

6. Additional comments:

2.2 THE BASIC LABORATORY DEMOGRAPHICS

2.2.1 Laboratory Completion Rate

By the extended deadline of December 2000, sets of results from 85 laboratories had been received. The list of participating laboratories, as well as the technique used, are shown in Table 2.2. This represents a completion rate of 75%, which is extremely successful and exceeds that recorded in the previous intercomparison (TIRI). The reported results are provided in Appendix 1.

Table 2.2 Participating laboratories

Laboratory name	Laboratory type	Country
LATYR, La Plata	LSC	Argentina
Pabellón INGEIS	LSC	Argentina
CSIRO, Glen Osmond	Direct Absorption	Australia
ANTARES AMS Centre, ANSTO	AMS	Australia
Arsenal Research	LSC	Austria
VERA, Universität Wien	AMS	Austria
VRI, Institut für Radiumforschung und Kernphysik	GPC	Austria
IRPA, KIK	LSC	Belgium
IGSB, Minsk	LSC	Belarus
Environmental Isotope Lab, University of Waterloo	LSC	Canada
AECL, Chalk River	Direct Absorption	Canada
Geological Survey of Canada (GSC)	GPC	Canada
EHPL-Env, Ontario Hydro	Direct Absorption	Canada
IOEE Chinese Academy of Sciences	LSC	China
Ruđjer Bošković Institute	GPC	Croatia
Institut für Fysik, University of Aarhus	AMS	Denmark
Institute of Geology, Tallinn	LSC	Estonia
Geological Survey of Finland, Espoo	GPC	Finland
University of Helsinki	GPC	Finland
IPSN/LMRE, Orsay	LSC	France
HIGL, Paris-Sud University	AMS (GIF)	France
Tandetron-Gif	AMS	France
Université Claude Bernard, Lyon	LSC	France
Umweltforschungzentrum Leipzig-Halle	LSC	Germany
Leibniz, Universität Kiel	AMS	Germany
IUF, Universität Köln	GPC	Germany
UFZ-CER, PRG, Halle	LSC	Germany
Institut für Bodenkunde, Universitat Hamburg	LSC	Germany
Heidelberg University	GPC	Germany
DAI, Berlin	GPC	Germany
IGR, NLB, Hannover	GPC	Germany
Universität Erlangen, Nürnberg	AMS	Germany
LOIH, Institute of Physical Chemistry, Demokritos	LSC	Greece
LOA, Institute of Materials Science, Demokritos	GPC	Greece
Institute of Nuclear Research, HAS	GPC	Hungary
Physical Research Lab, Earth Sciences Div, Ahmedabad	LSC	India

Table 2.2 Participating laboratories *(Continued)*

Laboratory name	Laboratory type	Country
Physical Research Lab, Radiocarbon Dating Lab, Ahmedabad	LSC	India
Birbal Sahni Institute, Lucknow	LSC	India
CRDIRT, JCPJ, Jakarta	LSC	Indonesia
University College Dublin	LSC	Ireland
Kimmel Center, Weizmann Institute	LSC	Israel
RDL, University of Rome, La Sapienza	GPC and LSC	Italy
Kyushu Environmental Evaluation Association	LSC	Japan
Institute for Advanced Science, Osaka	LSC	Japan
Palynosurvey Co	LSC	Japan
CCR Nagoya University	AMS	Japan
Gakushuin University, Tokyo	GPC	Japan
Kyoto Sangyo University	GPC	Japan
Seoul National University	AMS	Korea
Institute of Geology, Vilnius	LSC	Lithuania
RJ van de Graaff Lab, Utrecht	AMS	Netherlands
Center for Isotope Research, Groningen	GPC/AMS	Netherlands
Rafter Lab, Institute of Geological Sciences	AMS	New Zealand
University of Waikato	LSC	New Zealand
Radiological Dating Laboratory, Trondheim	GPC	Norway
Silesian Technical University, Gliwice	GPC	Poland
Archaeological and Ethnographical Museum, Łódź	LSC	Poland
Instituto Technológico e Nuclear, Sacavém	LSC	Portugal
Geological Institute, RAS	LSC	Russia
Geographical Research, St. Petersburg State U.	LSC	Russia
Institute of Geography, RAS	LSC	Russia
Institute of Ecology and Evolution, RAS	LSC	Russia
Institute of History of Material Culture, RAS	LSC	Russia
Instituto de Química-Fisíca Rocasolano, Madrid	LSC	Spain
University of Granada	LSC	Spain
Facultad de Química, Universitat de Barcelona	LSC	Spain
Tandem Lab, University of Uppsala	AMS	Sweden
Universitat Bern	GPC	Switzerland
ETH, Zurich	AMS	Switzerland
Department of Geology, NTU	LSC	Taiwan
Office of Atomic Energy for Peace	Direct Absorption	Thailand
School of Geosciences, Queen's University, Belfast	LSC	UK
Research Lab for Archaeology, Oxford	AMS	UK
SUERC, East Kilbride	LSC and AMS (AA)	UK
NERC Radiocarbon Lab	LSC/AMS (AA)	UK
Lab of Radioecology, KIEV	LSC	Ukraine
USGS, Reston	AMS (LLNL)	USA
Beta Analytic Inc, Florida	LSC and AMS (LLNL)	USA
NSF, Arizona	AMS	USA
Geochron Labs, Cambridge, Massachusetts	LSC/GPC/AMS (LLNL)	USA

Table 2.2 Participating laboratories *(Continued)*

Laboratory name	Laboratory type	Country
CAMS/LLNL	AMS	USA
NOSAMS WHOI	AMS	USA
INSTAAR, University of Colorado at Boulder	AMS (WHOI)	USA
University of California, Riverside	AMS (LLNL)	USA
ISGS, Illinois	LSC	USA

In summary, the broad geographical distribution for the laboratories is shown in Table 2.3 below.

Table 2.3 Geographical distribution

Broad geographical description	Number of laboratories
Europe (EU)	35
Europe (non EU)	17
North America and Canada	13
South America	2
Asia and the Far East	13
Australia and New Zealand	4

The summary of the numbers of laboratories using the different techniques is shown in Table 2.4.

Table 2.4 Laboratory type

Laboratory type	Number
LSC	44
GPC	19
AMS	17
Target feeder for AMS	8
Direct absorption and LSC	4

Thus, almost half of the participating laboratories use liquid scintillation. Virtually all operational AMS facilities participated.

Although we have a total of 85 identified participating laboratories, several laboratories operate different independent measurement systems; thus, the total number of submitted sets of results (92) exceeded this figure. Eight laboratories submitted results for AMS, through target preparation and then measurement in a remote facility. In 2 such cases, these samples were measured at the NSF Arizona facility; in 4, the analyses were performed at CAMS/LLNL; while 1 was measured in Tandetron-Gif and 1 measured at NOSAMS WHOI. These sets of results were treated as independent. Some laboratories also submitted more than 1 set of results for a given sample.

2.3 MODERN STANDARD AND BACKGROUND MATERIAL

Other potentially useful general information, which was collected at the time of the submission of results, concerned the background and modern standard materials used by the laboratories, the method of pretreatment applied (if any), the number of routine analyses performed per yr, and information about the measurement of $\delta^{13}C$. Not all laboratories provided all of this ancillary information. The background and modern standard materials used are surprisingly diverse, but have been broadly categorized to allow a simple summary shown in Tables 2.5 and 2.6 below.

Table 2.5 Classifications used for background and modern standard

a) Background

Original description	Coding for analysis
Anthracite	Anthracite (Anth)
Benzene	Benzene (Benz)
Calcite	Calcite (calc)
Charcoal	Charcoal (char)
Bituminous coal	Coal (coal)
Graphite	Graphite (graph)
Doublespar/IAEA C1	Marble
IAEA C4/wood/limestone	Other

b) Modern standard

Original description	Coding for analysis
ANU sucrose	ANU sucrose (ASUC)
Benzene	Benzene (Benz)
NIST OxI	NBS1
NIST OxII	NBS2
GIN/HD-95,C-3	Other
NIST 1/II	NBS12

Table 2.6 Numbers of laboratories using the identified background and modern standard materials

a) Background material

Classification of material	Number of laboratories using this material
Anthracite	12
Benzene	17
Calcite	3
Coal	4
Graphite	3
Marble	25
Other	27

b) Modern standard materials used

Analysis classification	Number of laboratories using this material
ANU sucrose	9
Benzene	5
NBS1	30
NBS2	29
NBS12	9
other	5

It is clear that there is a wide diversity of background materials, but marble and benzene are common and popular choices.

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We can see that the NIST Oxalic acids predominate, but that there are still a few laboratories (19) that do not make use of these materials. In addition, we considered whether the distribution of materials was associated with the different measurement techniques.

Table 2.7 Numbers of laboratories of each type by background and standard material used

a) Background material used

	Background material							
Laboratory type	Anth	benz	calc	coal	graph	Marble	other	**All**
AMS	3	0	2	0	2	15	8	**30**
GPC	6	0	0	3	1	4	3	**17**
LSC	3	17	1	1	0	6	6	**34**
All	12	17	3	4	3	25	17	**81**

b) Modern standard material used

	Standard material						
Laboratory type	ASUC	Benz	NBS1	NBS12	NBS2	other	**All**
AMS	1	0	16	9	5	1	**32**
GPC	1	0	7	0	7	3	**18**
LSC	7	5	7	0	17	1	**37**
All	9	5	30	9	29	5	**87**

c) Modern standard by background material used

	Background							
Standard	Anth	benz	calc	coal	graph	Marble	other	**All**
ASUC	1	1	1	1	0	3	2	**9**
Benz	0	4	0	0	0	0	0	**4**
NBS1	4	2	1	0	0	10	11	**28**
NBS12	0	0	1	0	0	6	0	**7**
NBS2	7	8	0	2	2	5	3	**27**
Other	0	1	0	1	1	1	1	**5**
All	12	16	3	4	3	25	17	**80**

There appears to be no strong evidence of an association between the background and modern standard material used with the measurement technique. It is clear that there are a number of commonly used background materials including, anthracite, benzene (only LSC), and marble (predominantly AMS). The NIST modern standards are widely used, but some laboratories do not make use of these materials and rely on ANU sucrose, benzene, and other materials.

2.4 HOW BUSY ARE THE LABORATORIES?

When submitting their results, laboratories were also asked to provide an approximate figure of the number of analyses they performed per yr. It was thought that this information might be helpful in understanding any outlier distribution and also in explaining deviations from sample consensus values and variation. A brief summary of the findings is presented in the following.

2.4.1 Number of Analyses Carried Out Per Year

The are 4 levels for the "number of analyses performed":

- *1* indicates <100 analyses done per yr by that laboratory;
- *2* indicates 100–200;
- *3* indicates 200–500;
- *4* indicates >500.

First, we consider the association between laboratory type and the number of analyses performed per yr.

Table 2.8 Numbers of laboratories in each Technique/Nr-of-analyses-per-year category

	Nr of analyses per yr			
Laboratory type	1	2	3	4
AMS	0	1	5	17
GPC	1	8	3	4
LSC	14	17	4	6
All	15	26	12	27

As expected, the AMS laboratories predominantly do over 500 analyses per yr (17/23 = 74%), while radiometric laboratories predominantly do fewer than 200 analyses per yr ([1+8+14+17] / (16+41) = 70%), particularly LSC labs ([14+17] / 41 = 76%)

Table 2.9 Numbers of results returned in FIRI by laboratories in each technique categorized by Number-of-analyses-per-yr category

	Number of analyses per yr				
Laboratory type	1	2	3	4	**All**
AMS	0	10	52	298	**360**
GPC	9	92	38	41	**180**
LSC	113	185	33	64	**395**
All	122	287	123	403	**935**

We note that the number of results submitted to FIRI per laboratory tends to increase as the number of analyses per yr carried out increases from an average of 8 (122/15) per laboratory for those doing less than 100 analyses per yr to 15 (403/27) for those doing over 500 per yr.

2.5 Conclusions

These demographic summaries indicate that there is a substantial diversity in the background and the modern standard material used by the laboratories. In particular, a number of laboratories do not routinely use the NIST primary standards. The background materials used are predominantly inorganic, which may prove a factor in the analysis of the Kauri wood samples (A and B). There is a substantial variation among laboratories in the number of analyses per yr which are performed. As would be expected, the AMS laboratories are typically performing substantially more analyses than the radiometric laboratories.

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