

## General Statement of $^{14}\text{C}$ Procedures at the National Ocean Sciences AMS Facility

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This statement applies only to samples analyzed as solid graphite produced at the National Ocean Sciences AMS (NOSAMS) facility. It does not apply to samples analyzed on the gas-accepting AMS system.

All laboratory preparations for AMS radiocarbon analyses of submitted samples occur in the National Ocean Sciences AMS (NOSAMS) Facility except for collagen extraction from bones which carried out by a specialist at Harvard University and returned to NOSAMS for further analysis. Procedures appropriate to the raw material being analyzed are described on our [web pages](#) in the Methods section. Pure  $\text{CO}_2$ , whether submitted directly or generated at the NOSAMS Facility, is reacted with Fe catalyst to form graphite. Graphite is pressed into targets, which are analyzed by accelerator mass spectrometry along with primary and secondary standards and process blanks.

An AMS measurement determines the ratio of  $^{14}\text{C}$  to  $^{12}\text{C}$  in an unknown sample relative to the ratio of the concurrently measured standard samples. At NOSAMS, the primary standard for  $^{14}\text{C}$  measurements is NBS Oxalic Acid I (NIST-SRM-4990). Every group of samples processed includes an appropriate blank, and a secondary standard analyzed concurrently with the group. Process blank materials typically include but are not limited to IAEA C-1 Carrara marble and TIRI F Icelandic Doublespar (Third International Radiocarbon Intercomparison) for inorganic carbon and gas samples; acetanilide (CE Elantech) or KHP (Sigma Aldrich) for organic carbon samples; a  $^{14}\text{C}$ -free groundwater for dissolved inorganic carbon samples; and a glycine (Sigma Aldrich) dissolved in DOC-free water for dissolved organic carbon samples.

Fraction modern ( $F_m$ ) is a measurement of the deviation of a sample's radiocarbon content from that of the modern standard. Modern is defined as 95% of the radiocarbon concentration (in AD 1950) of NBS Oxalic Acid I, normalized to  $\delta^{13}\text{C}_{\text{VPDB}} = -19\text{‰}$  (Olsson, 1970). A correction is made to normalize the sample result to a  $\delta^{13}\text{C}_{\text{VPDB}}$  value of  $-25\text{‰}$ , assuming a quadratic mass fractionation dependency. This correction is made using simultaneously measured  $^{13}\text{C}/^{12}\text{C}$  ratios on the AMS system. These  $^{13}\text{C}/^{12}\text{C}$  ratios are not reported. Post-analysis stable isotopic corrections are neither necessary nor appropriate for reported results. All  $\delta^{13}\text{C}$  results reported are measured on a split of sample  $\text{CO}_2$  by IRMS when requested.

Radiocarbon ages are calculated using the Libby half-life of 5568 years according to the convention outlined by Stuiver and Polach (1977) and Stuiver (1980). We do not report ages with reservoir corrections applied or ages calibrated to calendar year. If a sample collection date is specified on the submittal form, the  $\Delta^{14}\text{C}$  activity normalized to 1950 is also reported, i.e. the activity or  $\Delta^{14}\text{C}$  of the sample is corrected to account for the decay between collection (or death) and the time of measurement.

The  $^{14}\text{C}$  atoms contained in a sample are directly counted using the AMS method. Accordingly, we calculate an internal statistical error using the total number of  $^{14}\text{C}$  counts measured for each target (internal error =  $\frac{1}{\sqrt{n}}$ , where n is the number of  $^{14}\text{C}$  counts). An external error is calculated from the repeatability of multiple measurements of a given cathode over the course of a run (external error =  $\sigma/\sqrt{N}$  where  $\sigma = \text{sqrt}[\sum (X_i - \mu)^2 / N]$ , or standard deviation of the mean and N is the number of determinations). The final reported error is the larger of the internal or external error, propagated with errors from the normalizing standards and process blank corrections.

It should be noted that the reported error is an estimate of the precision (repeatability) of measurement for a single sample. Due to variability in sample homogeneity, sample collection, and sample processing, the variability of replicate samples (reproducibility) may be greater than the reported error for a single sample.

When publishing results of samples analyzed at the NOSAMS facility, we ask that an accession number (i.e. the reported OS-#####) be listed with the result along with any subsequently made corrections. Published results should acknowledge support from NSF by including the NSF Cooperative Agreement number, OCE-1755125. We encourage you to email references to your publications to [nosams@whoi.edu](mailto:nosams@whoi.edu) for inclusion in our web-accessible database of NOSAMS research related publications (<http://nosamsresearch.whoi.edu/>). Any sample material not consumed during sample preparation or AMS radiocarbon analysis, and not requiring refrigeration, is archived for two years at the NOSAMS Facility unless other arrangements are made by the submitter.

#### REFERENCES

- Olsson, I.U., 1970. The use of Oxalic acid as a Standard. *In* I.U. Olsson, ed., Radiocarbon Variations and Absolute Chronology, Nobel Symposium, 12th Proc., John Wiley & Sons, New York, p. 17.
- Stuiver, M. and Polach, H.A., 1977. Discussion: Reporting of  $^{14}\text{C}$  data. Radiocarbon, 19:355-363. [DOI:10.1017/S0033822200003672](https://doi.org/10.1017/S0033822200003672)
- Stuiver, M., 1980. Workshop on  $^{14}\text{C}$  data reporting. Radiocarbon, 22:964-966. [DOI 10.1017/S0033822200010389](https://doi.org/10.1017/S0033822200010389)