On extending the range of radiocarbon dating

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Radiocarbon laboratories worldwide routinely provide reliable ^{14}C dates in the 0-40 ka range to the geological and archeological communities. However, geochronologists widely recognize that the reliability of ^{14}C dating quickly degrades toward the end of this range and that ^{14}C ages older than ~40 ka are often inaccurate. The primary reason is that the amount of "original" ^{14}C used for age estimation in old samples (>40 ka) is very small (<1% of the initial total) and is extremely sensitive to contamination that may be introduced during burial, sampling, and/or laboratory processing. Recent progress has been made in removing contaminants through a variety of chemical techniques, including acid-base-oxidation-stepped-combustion (or ABOX-SC) of charcoal and ultrafiltration of bone collagen. However, these techniques are only as effective as the processes that are ultimately used to isolate the treated sample material. At the University of Arizona's Desert Laboratory, we recently constructed low-background vacuum extraction and graphitization systems that are dedicated to preparing old (40-60 ka) samples for ^{14}C dating. These systems are designed to minimize the amount of contaminant carbon, specifically atmospheric carbon, that is introduced to a sample during laboratory processing. Chemically treated samples are subjected to stepped-combustion in ultra-high-purity (UHP) O_2 to monitor the removal of contaminants. Interfering gases, including SO_X, NO_X, and halide species, are removed by passive chemical and cryogenic traps, and the resulting CO_2 is converted to graphite via catalytic reduction of CO. Graphite targets are stored in UHP Ar until measurement by accelerator mass spectrometry (AMS). For a 1 mg graphite target, the total procedural blank, including chemical pretreatment, combustion, cleanup, graphitization, storage, and AMS measurement, is 0.05±0.01 pMC (2σ), equivalent to a ^{14}C "age" of 61.1±1.8 ka. This should not be taken as the upper limit of our system, however, because if the ^{14}C activity of a sample is statistically indistinguishable from the appropriate mass-dependent blank value at the 95% confidence level, then its age is considered to be "infinite". Thus, for a 1 mg target, the practical limit of our system is actually ~55 ka; for a 0.5 mg target, the practical limit is ~50 ka. This represents an improvement of ~10-15 ka over the current limit.