Some Radiocarbon and Other Applications at the NSF-Arizona AMS Laboratory

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In this paper, we highlight some selected applications of AMS at the University of Arizona. We introduce some improvements in AMS system and chemical processing features as well as some interesting studies in ^{14}C dating of corals, speleothems and bones, ^{129}I studies; new records of ^{10}Be from marine sediments and extraterrestrial materials, and ^{26}Al measurements on extraterrestrial materials.

Today, an external precision of about $\pm$0.35% in ^{14}C content, or $\pm$30 years in uncalibrated radiocarbon age is possible on a single 0.5-milligram-sized sample target in 20 minutes of measurement time. Samples as small as 100 micrograms or less have been successfully dated to about $\pm$80 years BP and even smaller samples (~10-20 μg) have been measured for special experiments. With longer counting times or when multiple targets are measured, we can reduce the single target error to about 0.2%, or better than ±20 years in radiocarbon age (McNichol et al., 2001; Donahue et al., 1990).

In the case of longer-lived radionuclides such as ^{26}Al, ^{10}Be, ^{36}Cl, ^{41}Ca and ^{129}I, which were very difficult to measure using counting techniques, AMS has made measurements of small amount of these radionuclides. This increased sensitivity allows us to reduce sample size so as to preserve invaluable specimens such as archaeological samples, specially designed experiments in such as biomedical or nuclear sciences.

The NSF Arizona AMS Laboratory was one of the first purpose-built laboratories for radiocarbon AMS. For the past 25 years, the capabilities of AMS measurements of the Arizona AMS laboratory has been expanded to successfully include ^{10}Be, ^{26}Al, and ^{129}I. With continuous efforts of a few tens of active researchers and research associates at the laboratory, applications have been expanded from archeology to geology, oceanography, and atmospheric sciences. Jull and Burr (2006) and Jull et al. (2006) describe the history, current status, and future direction of the AMS research of Arizona AMS Laboratory.

Equipment. At the Arizona laboratory, we have 2 operational accelerator mass spectrometers (AMS). A large project was a thorough overhaul of our "original" machine, a General Ionex Tandetron, including installation of new HVEE accelerator tubes. Our second machine, a 3MV NEC Pelletron AMS has had a high level of operational time over the last 2 years. We have instituted programs in ^{129}I and ^{26}Al measurements, in addition to ^{14}C and ^{10}Be.

Service. Since 2001, the Arizona AMS facility has provided between 4500 and 6000 sample measurements per year, surpassing the previous 5-year average by more than 25%. In 2005 we produced 5,563 radiocarbon measurements and a similar number in 2006.

Fields of study: Our laboratory is involved in the study of a wide variety of radiocarbon and radionuclide studies, some examples of which are studies of corals, speleothems, lake sediments, ^{10}Be in marine sediments, dating of forest fires, dating of historical artifacts and textiles, terrestrial cosmogenic nuclides (e.g. Lifton et al., 2001) produced in situ in rock surfaces (which is part of a large international CRONUS program), extraterrestrial studies of radionuclides (^{14}C, ^{10}Be and ^{26}Al) in lunar samples and meteorites, ^{129}I in sea and groundwaters, ^{14}C in ground water using dissolved inorganic and organic carbon, and many others. We will discuss some examples of this wide-ranging program.

Sample pretreatment and processing. We have an ongoing program to improve and refine sample pretreatment and processing techniques. A few of the specialized techniques employed in the laboratory include soxhlet extraction for textiles, stepped combustion for sediments, partial dissolution for carbonates, and dissolved organic carbon (DOC) extraction for groundwater and ninhydrin extraction of carboxyl carbon from amino acids.

Limits of Radiocarbon Dating: In collaboration with Quade et al., we have developed a new low-level ^{14}C Extraction and Graphitization Systems at the University of Arizona's Desert Laboratory. We have also identified ion-source questions which have contributed to variable radiocarbon blanks in the past. The recent successful construction of These Systems has reduced laboratory-induced contamination during the combustion and graphitization phases of sample preparation nearly an order of magnitude and extended the ^{14}C dating horizon from about 40,000 to about 60,000 years before present. This advance can only be exploited if it is coupled with improvements in the chemical decontamination of samples prior to combustion. Our objectives are three-fold: (1) to develop sample handling methods and quantify the practical limits of ^{14}C dating of bone, charcoal, and carbonates using the new extraction and graphitization systems, (2) to apply these new methods to ^{14}C dating materials from Old World archaeological sites, and (3) to participate in establishing a firm calibration of ^{14}C ages between 40 and 60 ka.

We hope that this review will give an idea of the breadth of the studies undertaken at the University of Arizona AMS Laboratory.

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