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Review of development of AMS in the past 30 years and future perspective

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One of the main aims of Quaternary research is to understand global environmental changes of the past and to predict the expected changes in the near future. To pursue this aim, high-resolution age estimation is particularly important. Dating methods so far used for Quaternary research can be classified into five categories: (1) age estimation based on the decay procedure of cosmogenic radioisotopes such as radiocarbon (14C) and 10Be, U-series nuclides and a K-Ar pair; (2) age estimation by cumulative dose from natural nuclear radiation and cosmic rays such as TL, OSL, ESR, FT dating methods; (3) age estimation with geological or geochemical evidences of prehistoric events such as paleomagnetic reversals or excursions, oxygen stable-isotope-ratio variations, tephra stratigraphy; (4) age estimation with paleontological records of prehistoric events such as diatom, pollen, nanno-plankton and shellfish assemblages, as well as semi-global fluctuations of tree ring width; (5) age estimation based on archeological evidences. These dating methods are selectively applied dependent on the characters of geological and archeological events to be analyzed. Among the radio-isotopic dating methods, 14C dating is most frequently used because of its applicability to many different types of Quaternary samples, as well as age range covered by this method (a few hundred to 50,000 yr BP).

Developments of accelerator mass spectrometry (AMS) have triggered a wide area of application in radiocarbon (14C) dating. The AMS system requires only 1mg of carbon in precise determination of 14C/12C and 13C/12C isotope ratios, and this advantage has broadened the applicability of 14C measurements. Nowadays, AMS contributes to almost all kinds of research that utilize 14C dating in archeology, cultural property science, geology, and those that employ 14C tracer in environmental sciences, medical sciences and even forensic studies.

For example, a Tandetron AMS system dedicated to 14C measurement was installed at Nagoya University, and its routine operation for 14C measurement was started in 1983 for the first time in Japan. In 1996, another AMS system (HVE-Model-4130-AMS) was purchased and has been used for high precision 14C measurements. By 30 minutes measurement of carbon isotopes repeated for consecutive three days for a sample, one-sigma uncertainty of +-17 to +-30 years is achieved. A reproducibility test for 2000-year-old archeological samples yielded a fluctuation error as small as +-11 years. We also have evaluated accuracy in our 14C measurements by participating in international 14C inter-comparison tests, and confirmed that our14C results were quite consistent with the consensus values by all the participants. After the critical tests, we are sure that our AMS system can be applicable to historical samples that require high precision as well as high accuracy 14C measurements.

Quite frequent applications of 14C dating with AMS to the Quaternary samples in the last bidecade are promoted by the following reasons: (1) a very small amount of carbon (about 1mg of carbon for the final target preparation) is required; (2) uncertainties of 14C ages are from +-17 to +-30 yr, mainly owing to the 14C counting statistics; (3) calibration of 14C age to the calendar age scale become quite popular, for 14C ages up to 50,000 cal BP; (4) marine reservoir effect on 14C age has been recognized and investigated recently, and a realistic correction for the effect is becoming possible partly.

Along with 14C, other cosmogenic radioisotopes such as 10Be, 26Al, 36Cl, 129I are also measured with AMS systems. We briefly describe history of development of domestic AMS groups as well as worldwide AMS groups, along with the research fields of AMS applications and future perspective.

Keywords: accelerator mass spectrometry, cosmogenic nuclides, radionuclide, age measurement, ion nuclide separation, ion particle counting