# Contributions of Activation Analysis to Cosmochemical Research

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Cosmochemistry aims to understand the origin and evolution of the Solar System through the chemical and isotopic study of extraterrestrial materials. Among these materials, primitive meteorites are particularly important because they preserve records of processes that occurred during the earliest stages of Solar-System formation. Accurate elemental abundances obtained from meteorites provide fundamental constraints on the distribution and evolution of elements in the solar nebula and on subsequent parent-body processes. Activation analysis has played a significant role in cosmochemical research for several decades owing to its high sensitivity, accuracy, and freedom from many analytical biases. In particular, prompt gamma-ray activation analysis (PGAA) and radiochemical neutron activation analysis (RNAA) have provided unique information on volatile and trace elements in meteorites that is difficult to obtain by other analytical methods.

This talk reviews the contribution of activation analysis to cosmochemistry through studies of carbonaceous chondrites. The first part focuses on the application of PGAA to Antarctic carbonaceous chondrites, especially Yamato-type (CY) chondrites. Because PGAA permits the non-destructive determination of hydrogen, chlorine and major rock-forming elements, it is particularly suitable for the analysis of rare meteorite samples. The chemical characteristics of CY chondrites revealed by PGAA measurements provide important constraints on the effects of aqueous alteration and thermal metamorphism in primitive asteroidal materials. The second part highlights the application of RNAA to the determination of halogen elements in carbonaceous chondrites. Radiochemical separation following neutron irradiation enables highly reliable measurements of chlorine, bromine, and iodine at trace and ultra-trace concentration levels. The method minimizes the influence of contamination and allows chemical yields to be determined directly, resulting in robust abundance data. Recent RNAA studies of CI, CM, CO and CV chondrites have clarified systematic variations in halogen abundances among carbonaceous chondrite groups and provided new insights into the behavior of volatile elements during the formation and evolution of the Solar System.

The combined use of PGAA and RNAA demonstrates the continuing importance of activation analysis in modern cosmochemistry. These complementary techniques provide unique information on hydrogen and halogen elements, which are key tracers of volatile-element evolution in primitive meteorites. Future studies integrating activation analysis with mineralogical and isotopic investigations will further improve our understanding of aqueous alteration, thermal processing and volatile-element evolution in the early Solar System.