INSTRUMENTAL NAA OF CARBONATE ROCKS AND ITS APPLICATION FOR THE ANALYSIS OF SECONDARY SEDIMENTARY ENVIRONMENTS IN SHALLOW SEA

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Aiming at distinguishing between the sedimentary environments in shallow sea using elemental geochemical markers, the determinations of trace elements in carbonate rocks by thermal neutron, epithermal neutron and short-irradiation activation analysis have been studied, and more than 30 major and trace elements determined. Al, Cl, Sc, Ti, V, Cr, Fe, Co, As, Br, Rb, Sb, Cs, Lu, Hf, Ta, Th and U were found to be the effective distinguishing markers for the secondary environments in shallow sea.

Introduction

Carbonate rocks, making up 1/5th of the area of sedimentary rocks, are distributed widely. In China, sedimentary rocks account for 75% of the national area, of which 55% are carbonate rocks, and they are distributed almost in every geological period. With the development of geological and geochemical studies on carbonate rock areas, the demand on the determination of trace elements in carbonate rocks is more and more pressing. Yet the determination of trace elements in carbonate rocks is a difficulty because of the extremely low concentrations of these elements.

The elemental geochemical method for analysis of sedimentary environments has been developed in recent years because of the polykeys of the conventional sedimentary petrological, palaeontological and paleoecological methods and marks. B, Mg, Cl, K, Sr, Ba, etc., have been used to distinguish between the continental and marine environments successfully. But the developing history of this new method is relatively short, very few elemental marks of secondary environments in an ocean or a continent have been researched. Meanwhile, because modern analytical techniques such as NAA have insufficiently used for sedimentary environment analysis, many trace elements with important environment significances almost have not been studied and applied.

In this study, more than 30 major and trace elements in early palaeozoic carbonate rocks with shallow marine facies were determined by instrumental NAA and element
concentration differences in the carbonate rock samples from various secondary environments in early palaeozoic shallow sea, north China were discovered for the first time, and the elemental marks were employed to distinguish between the environments effectively.

**Experimental**

In carbonate rocks, the concentrations of most trace elements, ranging from 0.01 to 1 µg/g, are much lower than those in most silicate rocks and other types of sedimentary rocks. Major elements, except Ca, such as Na, Al and Fe are also very low. Just because of the low contents of the elements with the target nuclides forming major activities in rock samples by thermal neutron activation, the constitutions of the γ-ray spectra of the carbonate rocks are relatively simple, and the scattering backgrounds are relatively low, which are advantageous to the analysis. But the extremely low concentrations of the trace elements make it necessary for us to employ favourable experimental conditions to improve the detection limits to meet the needs of the research. Thus, a relatively high integral neutron flux, large sample size, short cooling time and long counting time were adopted, and epithermal neutron activation and short-irradiation were utilized.

**Analytical standards**

NBS SRM 1633a (fly ash), Dolomitic limestone NBS88b, China’s SRM GSR2 (hornblende andesite) and GSR6 (carbonate rock) were used as standards and analytical quality control samples.

**Irradiations and apparatus**

Irradiations were carried out in a pool nuclear reactor with a power of 3 MW of the Southwest Research Institute of Nuclear Physics and Chemistry, Chengdu, China. For short-lived nuclides, a rapid pneumatic system was employed.

The counting system consisted of a HPGe detector (with a detection efficiency of 20% and a resolution of 1.95 keV for the 1332 keV peak of 60Co) and a multichannel analyzer controlled by an IBM-PC/xt microcomputer.

The conditions of the irradiations and measurements are shown in Table 1.