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PIXE analysis of heavy metals in water samples from a mining area in Mongolia

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Abstract

The affect of mining activity on the environment has been long of public concern. The present paper deals with chemical analysis of the Boroo River water samples collected in mining area of Mongolia focusing the determination of heavy metal contents by particle induced X-ray emission (PIXE) technique. The samples were prepared by preconcentration method (water samples treated to form metal–dibenzyldithiocarbamate (DBDTC) complexes and collected on a nuclepore track-etch membrane filter) and irradiated by 2.5 MeV proton beam from the single-end type Van de Graaff accelerator. The accuracy of the results was proved by using certified river water samples. The total dispersions of experimental procedure were evaluated by variance analysis.

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Keywords: PIXE; Preconcentration method; Heavy metals; Dispersion; Variance analysis

1. Introduction

Environmental pollution from mining activity is one of the major concerns around the world. Mining generally releases toxic heavy metals such as arsenic (As), cadmium (Cd), lead (Pb) and mercury (Hg). The adverse effects of mining activity on the environment as well as human health have been observed in many areas [1–3].

Gold ore is usually associated with sulfide minerals such as pyrite (FeS_2), galena (PbS), sphalerite (ZnS), arsenopyrite (FeAsS), and chalcopyrite ($CuFeS_2$). Oxidation of the sulfide minerals resulted from mining activity has been considered as a major source of the heavy metal pollution in the mining areas. Usually, gold is separated from the ore through amalgamation with Hg.

Although mining has become intensive in Mongolia in the past decade, reports on heavy metal status in water, sediments and soils in the mining areas are very limited. Recently, high concentrations of Hg were found in the Boroo River, which flows through gold deposit areas in the northern part of Mongolia [4].

The present paper aims to determine concentration of heavy metals in water samples from the Boroo River using particle induced X-ray emission (PIXE) technique. Application of PIXE in combination with concentration method was chosen since it gives the possibility to measure heavy metals at ppb levels [5].

As the results of analysis contain random and systematic errors introduced at different stages of the analytical procedure, the total dispersions for determined elements were also evaluated by variance analysis method.

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2. Materials and methods

2.1. Water samples

Thirteen water samples were collected from the Boroo River in July 2004. Sampling locations are shown in Fig. 1. Bornuur Village with population about 4200 people is located in this area and inhabitants are extensively engaged in small-scale gold mining (Fig. 2).

The samples were taken in acid-washed plastic bottles and acidified (pH < 2) with HNO_3. All samples were refrigerated at 4 °C until analysis. The pH of the water samples were measured by electrode method using a pH-meter (Tokyo, Japan).

Fig. 2. The miners and their family are mining near the Boroo river of Bornuur village.

2.2. Experimental procedure

Targets for heavy metal content analysis were prepared by using the preconcentration method reported previously [5,6]. In this method, molybdenum (Mo) was used as an internal standard. The flow chart of preconcentration method is illustrated in Fig. 3. The targets were irradiated by 2.5 MeV proton beam from the single-end type Van de Graaff accelerator of Tokyo Institute of Technology (Tokyo, Japan). The proton beam was collimated to give

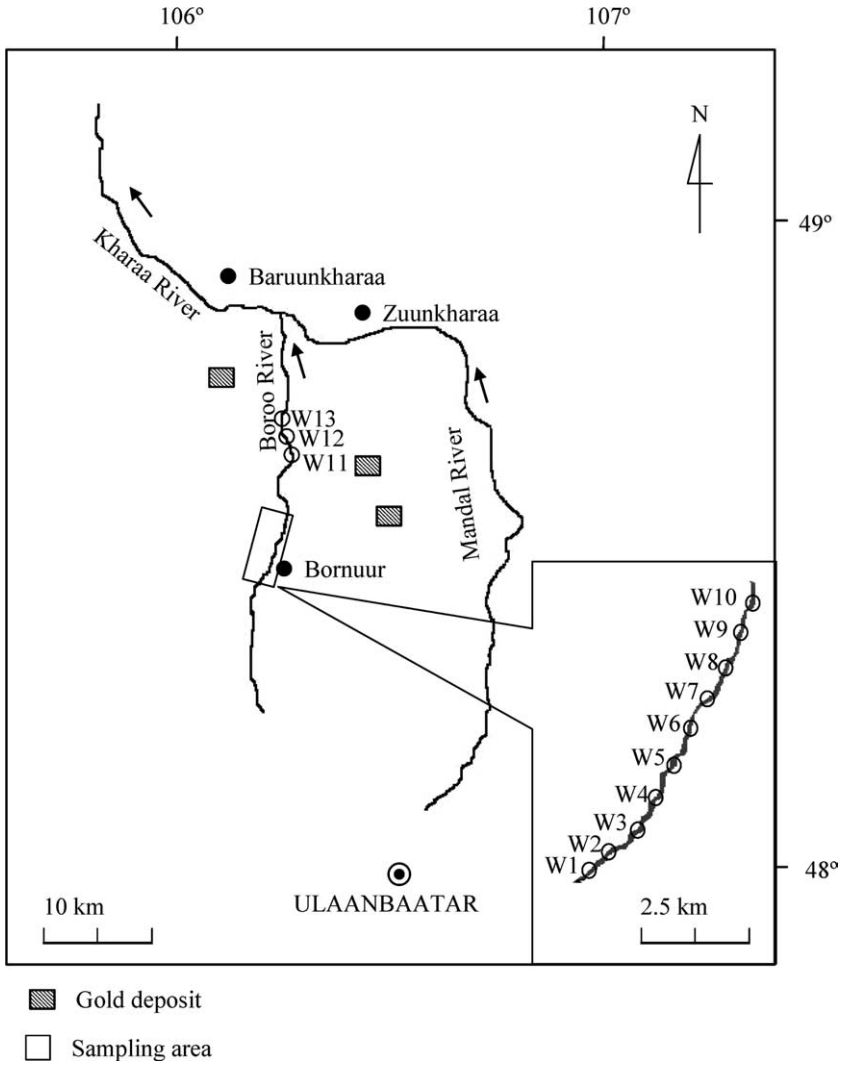

Fig. 1. Location map of study area in Bornuur district.