STUDY ON OCCURENCE FORM OF PLATINUM IN XINJIE Cu-Pt DEPOSIT BY NAA AND SCANNING PROTON MICROPROBE*

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ABSTRACT

A combination of NAA and micro-PIXE was used to study concentrations and distributions of platinum group elements (PGE) in ores from Xinjie Cu-Pt deposit. The NAA results of the bulk indicate that the ores belong to the enriched Pt-Pd type. The element concentration maps of scanning micro-PIXE for the ores show that the occurence form of Pt is independent arsenide minerals. No PGE were detected in chalcopyrite of Xinjie Cu-Pt deposit. These information are economically beneficial to the mineral smelting process.

Keywords Platinum group elements, Neutron activation analysis, Scanning proton microprobe, China

1 INTRODUCTION

The Xinjie stratiform complex is situated in Western Miyi County of the Sichuan Province. The complex consists of ultramafic-mafic rocks. The Xinjie Cu-Pt deposit is within the base of the complex. Layer Pt orebodys are enveloped by orthopyroxenes and peridotites.

Within the past decade, a fairly large number of petrological and mineralogical studies have been published on Xinjie complex and the Cu-Pt deposit[1~3]. On the other hand, there have been few reports on the study of the occurence form of Pt in the deposit. This may be caused by the lack of high sensitive, multielemental bulk and in situ analyses for the ores.

It is well known that the neutron activation analysis (NAA) and the scanning proton microprobe (SPM) provide ideal means to study PGE (platinum group elements) concentrations and distributions. They were successfully applied to search for PGE in economic sulfide deposits[4~6].

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This investigations were concerned with the occurence form of Pt in ores of Xinjie Cu-Pt deposit. At first, the bulk analyses of PGE in the ores were made by NAA to understand PGE mineralizing features of the ores. Further, the scanning micro-analyses of the ores in situ were accomplished by SPM in order to get element concentration maps in micron scale areas.

2 EXPERIMENT

2.1 Sample preparation

The ore samples were collected from the drilling cores of the deposit. Each of the core sample was divided into two parts. A portion of the two parallel samples was milled into 200 mesh powder for the NAA. The other was cut into slices and their surfaces were polished for the SPM.

2.2 Neutron activation analysis

Preconcentration NAA method was adopted for determining PGE in the ores. A nickel sulfide fire assay technique was used to extract the PGE from ores before NAA. Details of the technique have been described elsewhere[7,8]. A mixture of sodium tetraborate 40 g, sodium carbonate 20 g, silica 4 g, nickel powder 1 g and sulphur 0.5 g was added to 20 g of the samples. The fusion was carried out at 1000°C for 2 h in an electric maffle furnace. The ground bead material was dissolved in 300 ml 6 mol/L hydrochloric acid for boilling 1 h. The solution was filtered. The sulfide residues of the PGE was analysed by NAA.

The samples were irradiated at the swimming pool reactor in the Southwestern Institute of Nuclear Physics and Chemistry, Chengdu. The samples and chemical standards of PGE were put into one capsule and irradiated for 7 h at the thermal neutron flux of 9.6×10^{12} neutrons·cm^{-2}·s^{-1}. Subsequent analyses were carried out with a HPGe detector (FWHM=1.80 keV, relative efficiency=20% at 1.33 MeV) connected to an computer multichannel analyser.

After the decay of 16 h, the samples and standards were counted for ^{109}Pd ($t_{1/2}$=13.4 h) at 88 keV. The samples and standards were allowed to further decay for 7 d and recounted for Pt as ^{199}Au ($t_{1/2}$ =3.14 d) and ^{191}Os ($t_{1/2}$ =15.4 d) with gamma ray energies of 158 and 129 keV, respectively. The third counting was made for ^{103}Ru ($t_{1/2}$ =39.4 d) and ^{192}Ir ($t_{1/2}$ =73.8 d) at 497 and 468 keV, respectively, after 4 weeks decay.

2.3 Scanning proton microprobe analyses

The Shanghai nuclear microprobe was used in the analysis. Details of the operation of the system have been reported in Refs.[9,10] and only some salient features are highlighted here.

A 3 MeV proton beam, generated by an NEC 4MU pelletron accelerator, was chosen for micro-PIXE. The beam was collimated upstream with an object diaphragm of 20 μm and the admittance was further limited with a second diaphragm of 0.75 mm at the centre of the microbeam formation tube. After the two diaphragms the beam current was down to 150 pA. The beam was focused to a spot of less than 5 μm in diameter by a Russian

quadruplet of quadrupole lenses. The focused beam was deflected by a set of coils to scan the beam spot over the area of interest at the sample surface. A fast random scanning mode was adopted.

Characteristic X-rays induced by the proton beam were detected with a Si(Li) detector with a 12.7 μm Be window at 135° with respect to the direction of the beam. In order to determine trace elements, a 200 μm Al absorber was placed in the front of the detector. Another 100 μm polycarbonate foil, placed in the front of the Al absorber, stoped backscattering protons to prevent gamma ray production in the Al absorber.

The microprobe working in event by event data collection was used as total quantitative scanning analysis. Each of the events, containing E, X, Y information, was accumulated on the computer in an unsorted data file. A sorting program was used to produce concentration distribution maps for elements in scanning areas. The quantitative analysis program for thick target TTSPM, developed at our laboratory, was performed to calculate elemental contents from micro-PIXE spectra.

3 RESULTS AND DISCUSSION

The results of NAA for PGE in the ores are given in Table 1. The results display a very wide range for the PGE contents. It is suggested that PGE are unhomogeneously distributed in the ores, forming discrete noble metal minerals and possibly occuring in solid solution in rock-forming minerals and sulfides. The average grade of PGE is about 0.514 g/t. This indicates that the deposit is a low-grade Pt deposit. Fig.1 shows the relative distribution of PGE in the ores. We found from the distribution that the ores belong to an enriched Pt-Pd type.

Table 1

Determination of PGE in Xinjie platinum ores $\mu g \cdot kg^{-1}$

Samples	Pt	Pd	Os	Ru	Ir	ΣPGE
X101-19	59.1	56.2	36.0	11.8	9.87	173
X101-17	36.6	37.2	14.2	9.87	5.61	104
X101-24	124	37.6	12.4	10.1	5.38	189
X181-15B	1010	487	25.1	17.8	50.9	1591
Average	301	155	21.9	12.4	17.9	514

Table 2

Determination of PGE in the sulfide standard 975# mg/kg

Elements	Pt	Pd	Ir	Os	Ru
x±SD ($n = 3$) this work	0.30±0.02	0.15±0.016	0.024±0.0013	0.024±0.0022	0.019±0.001
Reference values	0.3~0.2	0.16	0.024	0.027	0.022

In order to assure the analytical quality, a laboratorial quality control sample, 975# sulfide ore, was analysed. The results are presented in Table 2. It is shown that the analytical values of this work are in agreement with the reference values.

From above understanding of the PGE mineralizing features in the ores, the polished section of the sample (X181-15B) was chosen for micro-PIXE analysis. Before the

analysis, the slice was observed with an optical microscope to locate regions of interest. Major minerals in the regions are chalcopyrite and basic rock-forming minerals.

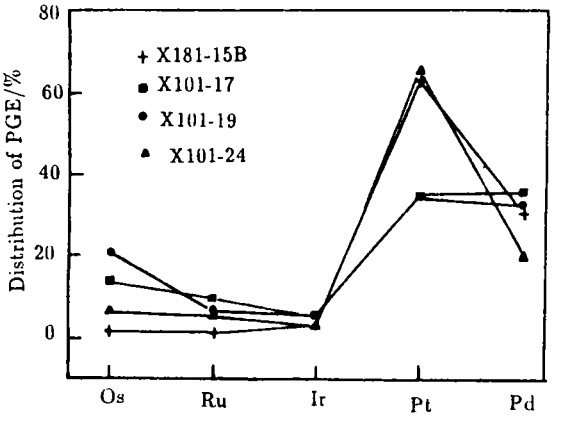

Fig.1 Relative distribution of PGE in the ores

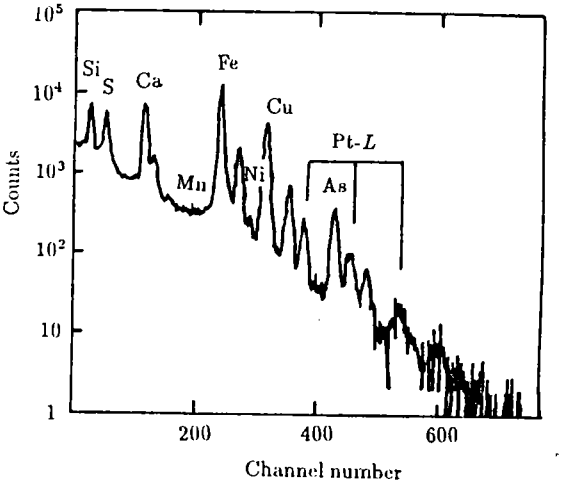

Fig.2 PIXE spectrum accumulated from the scanning area

Fig.2 displays the X-ray spectrum accumulated from a 100μm by 100μm scanning area in the section. In the spectrum, the peaks of characteristic X-rays of AsK and PtL are obvious. The concentration distribution maps for elements present in the scanning area are shown in Fig.3. From the maps, we could clearly see the strong coherence between As and Pt. We could also find that the elements Pt and As existed nearby elements S and Cu, and were surrounded by elements Si and Ca. These observations suggested that the element Pt occured as independent arsenide in the silicate matrix. The information are of interest in questions concerning the ore genesis and recovery research.

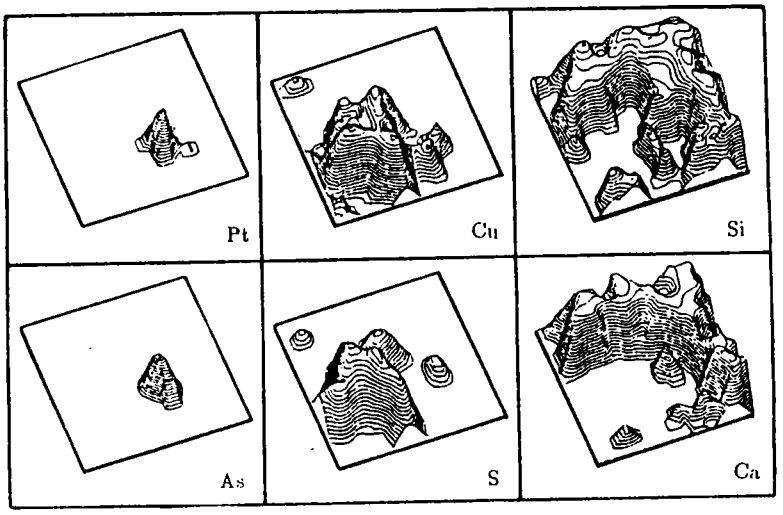

Fig.3 Element maps from the 100μm×100μm scanning area

Sulfide minerals are often considered as important carrier minerals for PGE. To identify distribution of PGE in the major sulfide, spot-analyses were done for the chalcopyrite in situ. Spot-analyses on noncontinuous areas were performed on all ten chalcopyrite grains. The PGE were not detected in the all chalcopyrite grains investigated. This suggested that the PGE did not significantly concentrated in the major sulfide mineral in the Xinjie Cu-Pt deposit. The ordinary relationship of net peak-counts >3 square roots of background-counts was used to determine the minimum detection limits (MDL). The MDL for PGE during this work was 60 μg/g for PtL_α, 6 μg/g for PdK_α, 8 μg/g for RuK_α and 9 μg/g for RhK_α.

4 CONCLUSION

This work has shown that the NAA and SPM are feasible for determination of PGE in platinum ores. The methods show us a great potential, with many applications in the fields of mineralogy and geochemistry of PGE deposits.

Our investigation has also shown that the distribution of PGE in Xinjie Pt ores belongs to the enriched Pt-Pd type. The occurance form of element Pt is the independent arsenide mineral.

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