APPLICATION OF INAA TECHNIQUE TO RESEARCH ON THE GEOGAS ANOMALY IN A GOLD DEPOSIT, SOUTHWEST CHINA*

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ABSTRACT

A new method of geogas (soil gas) collection and analysis, is briefly introduced. A geogas collector is buried at shallow depth to collect volatile compounds for a period of 60—90 days. The adsorbed compounds are analyzed by INAA. This paper presents the multi- elemental anomaly of a gold deposit, Southwest China.

The element contents and the multielemental anomaly of geogas were compared with those in the near- surface soil around the collector, background of the collector, and in gold ores. The geogas anomaly on gold deposit is demonstrated as a direct indicator of subsurface deposits.

Keywords: INAA Geogas Gold deposit Multielemental anomaly Background

Ⅰ. INTRODUCTION

The geogas analysis is a new method quite different from the well known gas survey, such as Hg, Rn and He survey, It is of multi- elemental indicators and deeper probing depth. The new method has been of interest in a number of application areas, such as the survey of mineral deposits[1], petroleum exploration[2] and studies of geological structures, groundwater and engineering geology[3] since the early 80's. These researchers used PIXE (Particle Induced X- ray Emission) and Mass Spectrometry technique to determine the element concentration of geogas. We started studying geogas anomaly on gold deposits in 1988, using Instrumental Neutron Activation Analysis (INAA) technique which is a sensitive and precise method determining the geogas on gold deposits.

The studied gold deposit is located in the hillyland area, Southwest China. The country rock of the deposit consists of silstones and pelite in Upper Jurassic, Alcaline porphyry, lamprophyre in Himalayan. There are Au, Ag, Cu- Pb- Zn mineralization near the contact zone between the intrusions and the sediments. Our study was carried out in one block of the gold deposits. The gold bearing veins occured along the fractures, dip to north with average dip angle of 65, deep to several tens of metres, up to 400 metres. Few of the ores were exposed on the surface. The mineral assemblage of the ore includes native gold, specularite, pyrite, quartz and baryte. The 72nd

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prospecting line was selected as a detective section of geogas research.

Ⅱ. EXPERIMENT OF INTEGRATIVE COLLECTION AND ANALYSIS

In the prospecting line 72, the collectors of geogas were buried with an interval 10 metres between two adjacent collectors in the gold mineralization portion, otherwise 20 metres. The collector was hung in a plastic funnel with a cup, and buried at depth of 50—60 cm, then backfilled. After 90 days, the equipments and collectors were dug out carefully, then the concentration of elements adsorbed on the integrative collectors were determined by INAA.

The collectors were kept in a desiccator for 24 hours under no man- made pollution, then folded into a size of 1 cm× 1 cm, put each collector into a small polypropylene pocket, the pocket was wrapped up with aluminium foil. Composed chemical standard was used in the determinations. 1571 (NIST, American) and tomato leaves reference (Chinese) were used for the analytical quality control.

The references, standards and samples (collectors) were irradiated for 20—30h at a neutron flux of $6\times 10^{12}n/cm^2 \cdot s$ in the pool— type reactor housed at the Southwest Institute of Nuclear Physics and Chemistry near Chengdu. In the measurement, all counting was made on the computerized multichannel analyzers connected to a pure Ge detector, with an energy resolution of 1.85 keV for 1332 keV, and a relative efficiency of 20%. Sequential counting of samples and standards was made to obtain results for Au, As, Sb, La, K, Sm, Na, after cooling time of 3 days; for Cr, Ag, Zn, Sc, Cs, Fe, Co after cooling time of two weeks. The concentrations of these elements are in the range of 10^{-1} to $10^2 ng/cm^2$. The analytical quality control is implemented in time to check out the reliability of analytical results.

Ⅲ. RESULTS AND DISCUSSION

The data of the elements determined have high reliability. Zn, K, Cr, La, Cs, Sc, Ag, Au, Sb, As have higher concentration (in ng/cm^2). But the value of the element alone is less important in anomaly recognition. The concentration of each element was plotted according to its location in the detective section, the variation of those element contents shows clear anomalies, especially for metallogeneous metal—Au. A very important feature is that each of 10 elements consistantly shows a clear anomaly on the same location along the 72nd prospecting line. The location of the multi- elemental anomaly is at the right upper of gold mineralized portion (Fig.1).

It is necessary for the evaluation of the anomaly to check if there is any contribution from soil to the collectors. We collected soil sample of 500 g at the location of each collector while we dug out the collectors after 90 days. The concentrations of 25 elements, Au, As, Ag, Sb, Cr, Hf, REE, K, Rb, Ba, Cs, U, Th, Zn, for each sample of soil were determined by INAA. The results were plotted on the section respectively. There are distinct difference in patterns and locations among the

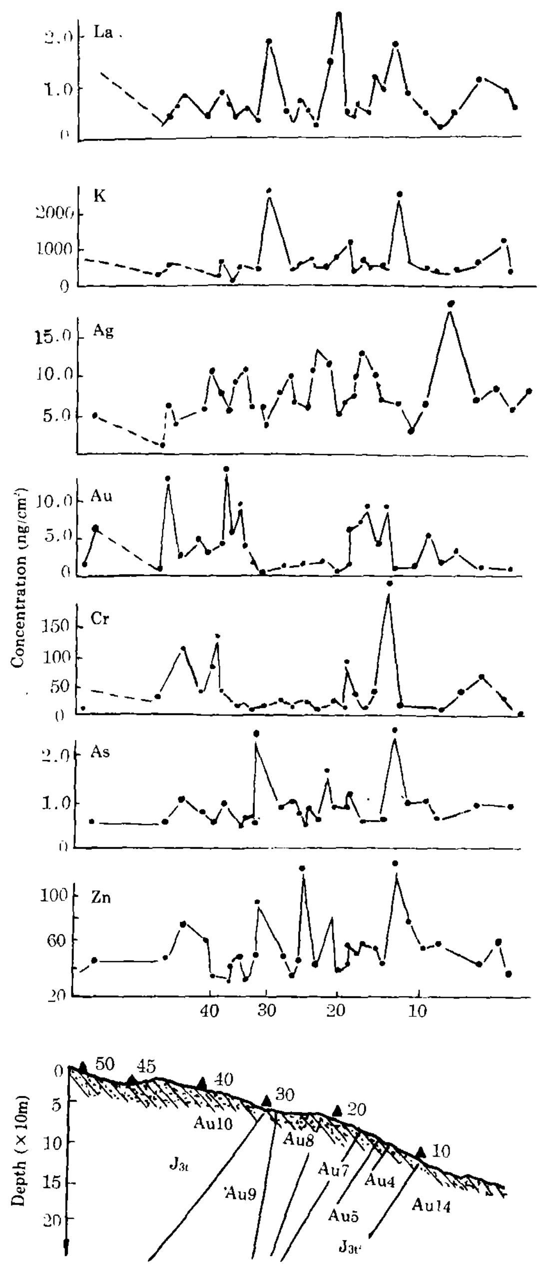

Fig.1 The cross section in the 72nd prospecting line showing multielement geogas anomaly

In the section, number shows the number of collectors, Au5 shows the number of gold vein

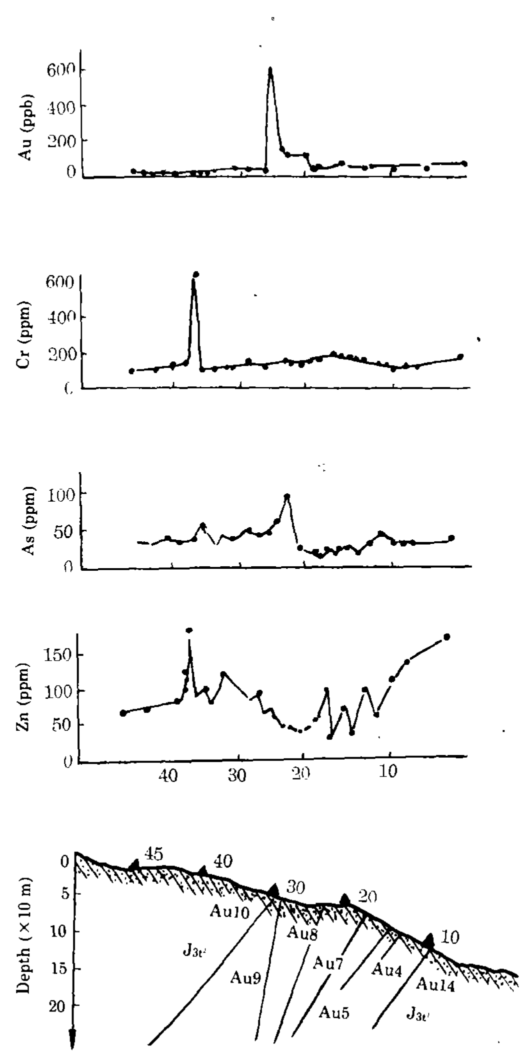

Fig.2 The cross section in the 72nd prospecting line showing the anomaly of some elements in soil around the collectors

section diagrams of soil and of geogas anomaly. There are unambiguous anomalies of

As, Sb, Au at the location of 21st- 27th collectors (Fig.2). This illustrates that the metals trapped on the geogas collectors came from the relative deep gold mineralization portion rather than from the soil near surface. The soil has little contribution to the anomaly of geogas. The elemental concentrations in soil on the exposure of mineralized structure are quite high.

Lowering the background of geogas collector is another very important problem. The background value of collector was reduced after washed and retreated the material used as a collector. The background of the material was determined and statistically evaluated. There are ±20% variation of background to the average value for 54% of the determined elemets; for 31% of the determined elements, in ranges of ± 80%; for Au, up to ±150%. This mains the collector's material is homogeneous for the most of elements, is less homogeneous for some elements, such as Au. But if we consider there are high ratio of anomaly value to background, for 83% of the determined elements, 2—4 times; for 16% of the elements, 10—30 times; for Au, 10—30 times; for Cr, 6—10 times, the variation of background values has slight effect on the anomaly values.

There are three groups of elemental assemblage in the geogas anomaly by R- model cluster analysis, namely Sm, Sc, La, K, Fe, As; Cs, Zn; and Au, Ag, Cr. This relationship can be seen in Fig.1. Each element of the three groups has an anomaly at the mineralized portion. The figure illustrates that there is systematic variation of the element contents in geogas anomaly as in gold mineralization. This may be an indicator of subsurface metal deposits.

Table 1

Element content of ore and mineralized rocks in the studied area (ppm)

Sample (amount)	Au (ppb)	As	W	Sb	Cr	Fe (%)	Co	Zn	K (%)	Na (%)	Rb	Cs	Ba	Sc
Mineralized aikali— porphyry (2)	51.2	6.35	9.65	0.76	37.4	4.1	32	11	4.5	3.08	198.5	3.8	4264.5	7.6
Mineralized lamprophyre (2)	186.5	63.7	166	3.45	35.6	28.7	11	86.5	1.1	0.04	138.5	3.4	25.5	7.47
Au- bearing specularite (4)	384.3	48.5	328.7	6.5	19.8	48.9	3.2	30.3	0.6	0.04	63.9	0.5	50	7.5
Au- bearing quartz- pyrite (3)	53.2	16.3	223.5	2.2	21..4	46.5	27.2	96.5	0.9	0.01	109	3.85	100.5	3.43
Ore (1)	21051	484	15	8.3	67	46.4	26.8	26	0.01	0.01	21.7	0.24	200	0.41

Another very important feature is that the elemental assemblage on the geogas anomaly is quite similar to that of gold ores. The trace element concentration of 12 ore samples from different type of the ores and different depths were determined by INAA (Table 1). These elements, based on the result of the R- model cluster analysis, can be subdivided into two groups, namely group K, Ta, Na, Rb, Co, Sc, Cs, Zn; and group Au, As, Cr, Fe, Sb, W. The content of Au is closely correlated to As, Cr, Sb. We believe that the metals on the geogas collector derived from the ores or mineralized zone beneath the surface. The kinds and contents of the elements on the collectors are relative to mineralization in bedrocks. The K, Na, Rb, Cs do not seem to come from the host rocks, even the rocks are rich in the elements, the anomaly of K, Na, Rb, Cs only presents at the mineralization portion. The conclusion may be drawn that the multielemental geogas anomaly is an indicator for subsurface gold deposits.

The migration of geogas may be caused by mini– bubble flow which contains the metals from the gold ore by decomposition or by emanation process. The mini– bubble flow with the metals moves up vertically, slowly through fractures or pores of rocks from the mineralization zone, and accumulates in the soil near the surface. The vertical drainage of groundwater may be another possible mechanism. The detail, therefore, on the form and migration process of the metals is still an open question.

The INAA technique was successfully used in the research of geogas, even though there are some questions to be further studied. This research is a basic study of a new prospecting method for the direct surface detection and characterization of metal deposits, especially for covered or blind deposit. Compared with the other techniques in the study of geogas, such as PIXE, Mass Spectrometre, the INAA can determine more elements with higher precision and reliability. It is also feasible and convenient in our country. We can expect this technique will be used in studying other metal deposits.

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