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Modified Geogas Survey: a Potential and Practical Tool for Mineral Exploration in areas with Exotic Overburden

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ABSTRACT

Geogas or metals-in-soil-gas survey has been tested for over 15 years in China and significant progress has been made since the development and adoption of liquid collector with active sampling procedure and ICP-MS analytical method. The liquid collectors are very low in trace metals and can be controlled with blanks. The liquid collectors can be accurately and directly analyzed with ICP-MS, which makes geogas detection more reliable and avoids the annoying digestion previously used for solid collectors. The results from a dozen of case studies including gold, polymetallic and nickel deposits show that metals in soil gas not only exist, but also can be enriched to more than tens of thousand ppb level in liquid collector samples and form anomalies with high signal to noise ratios above the known mineralizations in exotic overburden. It is believed that geogas surveying can be used as a potential and practical tool for mineral exploration in areas with exotic overburdens in near future.

INTRODUCTION

Mineral exploration is being irreversibly forced into covered terrains and explorers have to invest more and more in new technologies to probe the depth of covered areas. Soil gases are considered a tantalizing sample medium for mineral exploration in covered terrains because of their high mobility. Techniques for measuring soil gases were developed mainly for agricultural studies and petroleum exploration early in the last century. New techniques to measure soil gases like Soil Desorption Pyrolysis (SDP) (Thiede et. al., 2005; Windle et. al., 2006) and Soil Gas Hydrocarbons (SGH) (Sutherland et al., 2005), however, were developed to explore mineral deposits including gold, base metals, diamonds by geochemists in covered areas in recent years.

The term “geogas” was first used to describe the gaseous metals in soil pore spaces and detect mineral deposits by Malmqvist & Kristiansson (1984). The idea and technique were then introduced into China in early 1990s (Tong et al., 1991). Since then, the former Ministry of Geology and Mineral resources, the China Geological Survey and Natural Science Foundation Committee (NSFC) have continuously supported the research and application of the geogas surveying techniques in China. Before 1999, all researchers used solid collector to collect geogas in soils and there was not much progress in the actual application of the technique for years. This has been attributed to the fact that almost all solid collectors contain various quantities of metals which are difficult to be chemically or physically removed and will remain in the adsorbent during sample preparation and analysis. Concentration of trace elements detected through this kind of procedure is resulted from two sources; the solid collector and the soil geogas adsorbed, and is therefore considered unreliable for mineral exploration. Newly developed liquid collectors have improved the accuracy of the Geogas data because they are low in blank levels. The application of liquid collectors has avoided the time-consuming digestion and the aqueous medium can be easily analyzed by ICP-MS (Wang et al., in press).

In the past few years, several case studies were conducted on geogas survey with liquid collectors. Following are some results from orientation surveys over some polymetallic and precious mineral occurrences in north and northwest China.

With the improvement in collectors, the recent Geogas anomalies detected in soils over buried mineralization attest to the presence of metals in soil gas and confirm the effectiveness of this technique.

METHODS

There are two approaches to collect geogas in geogas studies: passive (Malmqvist & Kristiansson, 1984) and active collection (Wang et al., 1995). The passive collection with solid collectors (liquid absorber devices are hard to be designed) requires integrated sampling over long period of time, which makes the

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deploying and recovering of the sampling devices difficult. In the orientation surveys described in this paper, a modified active method was used in collecting geogas (Wang et al., in press). The sampling device consists of a cone-shape sampler, a Millipore filter (0.45μm), a liquid collector, and a battery operated pump. The liquid collector is a high density polyethylene (HDPE) bottle containing a certain amount of diluted HNO3 prepared in a clean room with ultra-pure HNO3 and deionized water. When sampling, the cone shape sampler is pushed 30-40 cm deep into soils, and the Earth gas is pumped through a silica gel tube and the Millipore filter to prevent coarse particles from entering the liquid collectors. The pumping lasts 2 minutes with a total of 3 L gas pumped at each hole. At each sampling site, a composite of samples is collected from three holes at an interval of 2~3m to improve the sampling reproducibility.

All samples including blanks are analyzed for 40 elements including Pb, Zn, Cu, Ag, Ni, Bi, Cd, Au, Mo, W with ICP-MS at IGGE Central Lab.

CASE STUDIES

Jiaolongzhang Polymetallic Deposit, Gansu

Jiaolongzhang polymetallic deposit is located in eastern Gansu and was discovered in 1974 with aeromagnetic survey. The polymetallic mineralization zone, which is 3600m in length, 200m in width and 300 to 500m in dip extension, is totally covered by loess (50~80m) and tertiary red sandstone (20~50m). The major commodities in the concealed orebodies are Zn, Pb-Zn and pyrite. The host rock consists of chlorite-quartz sandstone and limestone, and the main ore minerals include pyrite, sphalerite, galena and chalcopyrite. The bedrock, mainly composed of Ordovician intermediate and acidic marine volcanics, pyroclastics, and felsic sandstone, is exposed only at the bottom of gullies. Intrusive rocks are mostly granodiorite and plagiogranite porphyry.

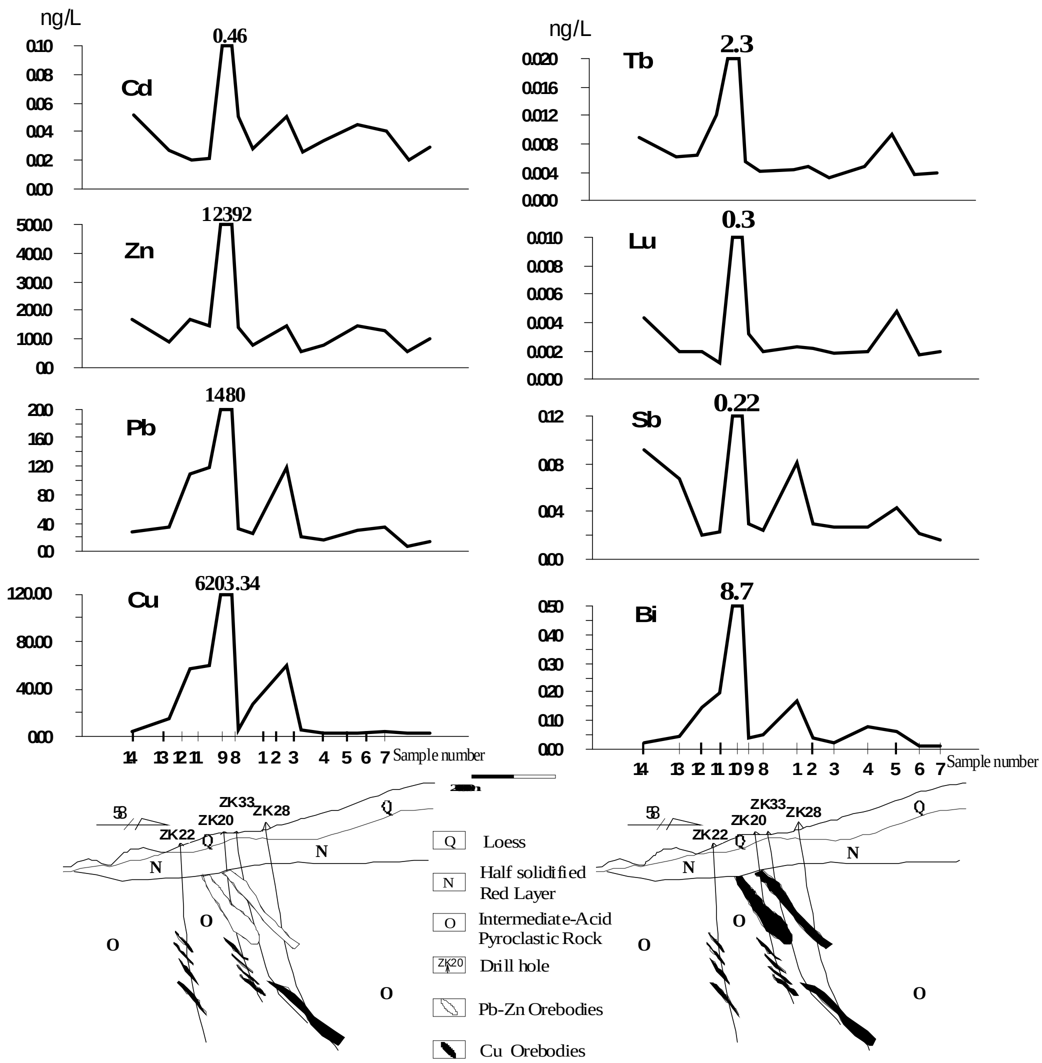

Figure 1: Distribution patterns of indicator elements in geogas on line 48 over Jiaolongzhang polymetallic deposit, Gansu province.

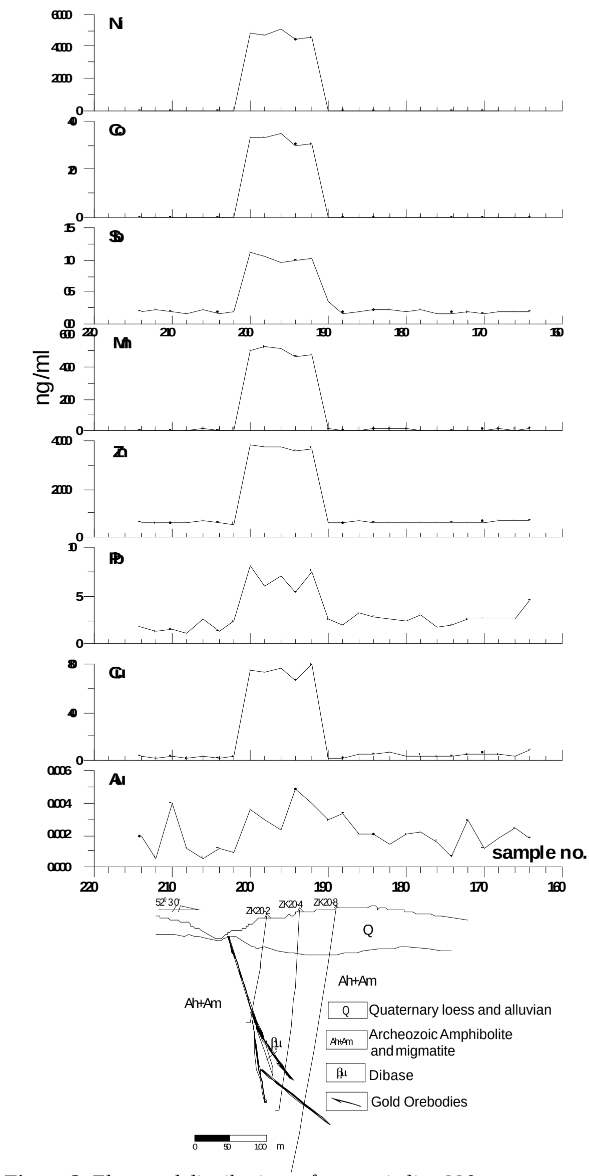

Figure 2: Elemental distributions of geogas in line 220 over Zhangquanzhuang gold deposit, Hebei.

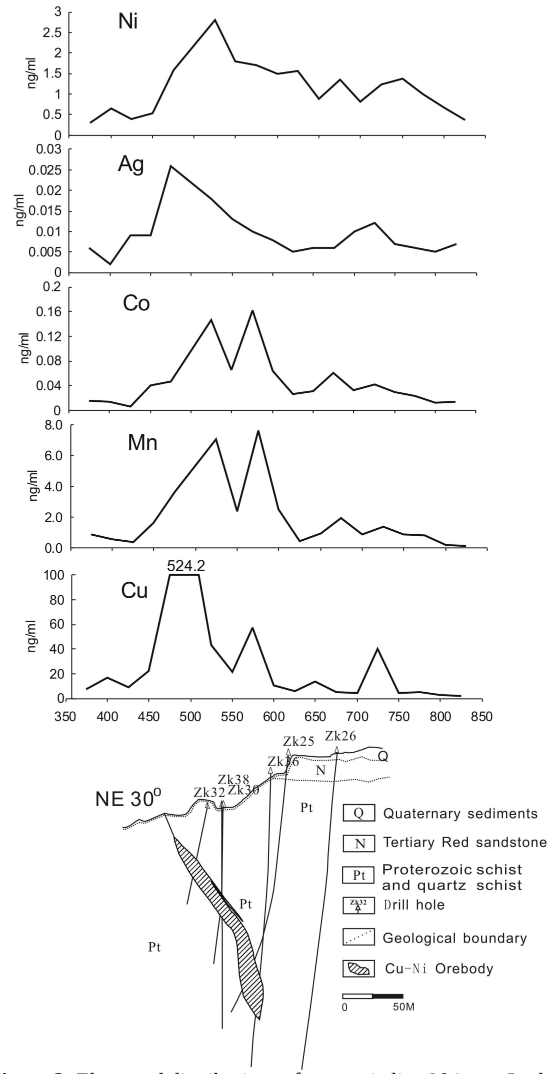

Figure 3: Elemental distributions of geogas in line 204 over Lashuixia Ni(Cu) deposit, Qinghai.

In comparison with wallrock, concentrations of a dozen elements including Pb, Zn, Cu, Ag, Cd, Ag, Bi are highly increased in orebodies and these elements are considered good indictors for geogas survey; and some elements like Rb, Ce, Tb, and Lu are slightly enriched in the ores.

Comparison of analytical results in the blanks with that in the sampled collectors from Jiaolongzhang polymetallic area shows the samples to be highly enriched in Ba (12×), Bi (96×), Ce (12×), Cu (106×), Pb (106×), Sr (12×), Tl (23×) and Zn(52×) and to a lesser extent in other indicator elements (1× to 9×).

Most highly enriched elements are those related to mineralization and the most significant contrast is detected in the anomalies of mineralized elements such as Pb, Cu, and Zn.

Distribution patterns of Cd, Zn, Cu, Pb, Tb, Lu, Sb, and Bi in geogas on line 48 are shown in Figure 1. The above elements increase markedly over the mineralization zone and can be used as direct indicators for the concealed mineralization. The Cu, Pb, Sb, and Bi in geogas show a double peak pattern over orebodies and the highest concentrations of Cu, Pb, and Zn are over 1ppm. The results from geogas survey in Jiaolongzhang area indicate undoubtedly that geogas anomalies can be detected in the soil gases over the concealed mineralization.

Zhangquanzhuang Gold Deposit, Hebei

Zhangquanzhuang gold deposit is located in Xuanhua county, Hebei province. Most of the area is covered with loess and alluvia from several to tens of meters in thickness.

The gold deposit (20 tons gold) is hosted mainly in Archeozoic amphibolite and migmatite. The ore is mainly composed of quartz and sulphides and is highly enriched in Au, Cu, Pb, Zn, Mn, Sb, Co, Ni, Cd, Ag, Rb, Cs, Hf and Ce.

Cu, Pb, Zn, Mn, Co and Ni above the gold ore zones formed obvious anomalies (Figure 2) and can be used as indicators for the concealed gold mineralization zone. Au, however, is only slightly higher over mineralized zone because gold is extremely low in geogas close to the detection limits of ICP-MS and hard to be collected by low concentration of nitric acid. More studies should be carried out to explore gold by geogas survey in covered areas.

Lashuixia Ni (Cu) Deposit, Qinghai

Lashuixia Ni (Cu) deposit, Qinghai has been mined for 20 years and only less than 5% of the previously defined reserve was left to the year 2005. So it is now quite urgent to find replenishing resources for the mine. On the other hand few tools can be used in exploring for concealed mineralizations because over 90% area was covered by Quaternary sediments and tertiary red sandstone. Pilot geogas survey in 2005 was designed to test the effectiveness of geogas survey in the area and delineate targets for test drilling.

Ni (Cu) orebodies was hosted mainly in a sequence of Proterozoic schist, quartz-schist and a small amount of gneiss. Average grade of the deposit is 4.2% Ni, 0.12-3.0%Cu, 0.01-0.2% Co and accompanying commodities of platinum group elements. Ore and gangue minerals include vialarite, pyrite, marcacite, chalcopyrite, quartz and plagioclase.

The distributions of Cu, Ni, Ag, Co, and Mn anomalies in geogas along Line 204 show that the anomalies of Cu, Ag, and Ni are much similar but response of Cu is particularly significant over known mineralization; Distribution patterns of Mn and Co are similar and peak values of these anomalies occur in the north of known orebodies (Figure 3). The results indicate that anomalous values of major indicator elements in geogas can be used in locating nickel (Cu) mineralization in covered areas.

CONCLUSIONS

After nonstop efforts on the application of geogas exploration over more than 15 years, a lot of valuable experience and solid progress have been achieved on the application of geogas survey in China.

Concentrations of trace element in the newly developed liquid collectors are very low and controllable in blank and the active sampling procedure with the liquid collectors has avoided the annoying digestion procedures routinely used in previous studies. The final aqueous medium can be accurately analyzed by ICP-MS and make the geogas observation more reliable. Obvious contrast between concentrations of various metal elements in the blank and those in the liquid collector samples have been observed and associations of anomalous indicator elements associated with known mineralization have been detected over buried mineralization. The above facts show that "gaseous metals" do exist in soil gas and can be used as a potential and practical tool for mineral exploration in areas covered with exotic overburdens.

REFERENCES

Malmqvist L. and Kristiansson K., 1984. Experimental evidence for an ascending microflow of geogas in the ground. Earth and Planetary Science Letters, 70, 407-416.

Sutherland D, Hoffman, E and Southam G., 2005. Soil gas hydrocarbons (SGH): penetrating predictive geochemistry using a forensic investigation with organic mineral signatures for mineral exploration. Association of Applied Geochemists, Nepean, ON, In: From tropics to tundra; 22nd international geochemical exploration symposium; program and abstracts. [Abstract, Book, Conference Document] Pages 138. 2005. [ISBN: 1-86308-119-4].

Thiede D. S., Windle S. J., Hall Gwendy E. M., McClenaghan M. B., and Hamilton Stewart M.2005. SDP soil-gas geochemistry at Cross Lake, Ontario (in From tropics to tundra; 22nd international geochemical exploration symposium; program and abstracts) Promaco Conventions, Canning Bridge, West. Aust., Australia (2005): 103-104.

Tong Chunhan, Li Juchu and Liang Xingzhong, 1991. Preliminary results of Geogas anomalies in a gold deposit (in Chinese). Academic Journal of Chengdu Geological College, 60, 116-121.

Wang Mingqi, Gao Yuyan and Liu Yinhan, in press. Progress in the collection of 'geogas' in China. Geochemistry: Exploration, Environment, Analysis.

Wang Xueqiu, Lu Yinxiu and Xie Xuejing, 1995. Dynamic collection of geogas and its preliminary application in the search for buried deposits (in Chinese). Geophys. Geochem. Explor. 19: 161-171.Windle Steve, 2006. New soil-gas chemistry technique effective under transport cover, Explore 122: 24-25.