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Geochemical Soil Survey for Au Exploration in the Kenieba District in Mali, Africa

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ABSTRACT

A Geochemical soil survey was carried out over an area of 50 km2 in Mali, Africa, in order to select the promising areas for gold occurrences. The survey area is situated in the southwestern part of Mali near the border with Senegal, and is located between 13°28´N - 13°32N and 11´31°W - 11°35´W, about 600 km northwest of Bamako, the capital of Mali. The survey area is underlain within the Kenieba inlier, composed of Birimian rocks (lower Proterozoic) surrounded by upper Proterozoic and Paleozoic formations. In the reconnaissance survey, a total of 2,597 soil samples were collected using the grid patterns of 200 m by 100 m, and an area of 10 km2 was selected for the detailed geochemical survey. During the detailed survey, a total of 2,146 soil samples were taken using the grid pattern of 200 m by 25m, and 80 termitaria samples were also collected. All samples were analyzed for Au and As after aqua regia digestion. From the reconnaissance survey, four Au and As anomalous areas were selected and the areas show similar directional patterns with the NS direction of the main regional fractures. From the detailed soil survey, two Au and As anomalous areas were finally proposed as promising prospects for Au occurrences.

INTRODUCTION

This is the brief report of "Geochemical exploration for the survey of the Kenieba project in Mali, Africa", which is the contract name between Korea Mining Promotion Corporation and Research Institute of Energy and Resources, Seoul National University. The exploration survey covered an area of 50 km2 in Mali, Africa. The project consisted of three stage field surveys as follows; the preliminary, the reconnaissance, and the detailed surveys. The purpose of the project is to select the promising areas for gold occurrences from the geochemical contour maps of Au and As in soil and termitaria, P romising areas for gold occurrences are proposed in this study.

DESCRIPTION OF THE SURVEY AREA

Geography and geology

The survey area is situated in the southwestern part of Mali near the border with Senegal, and is located between 13°28´N ~ 13°32´N and 11°31´W ~ 11°35´W, about 600 km northwest of Bamako, the capital city of Mali, Africa (Figure: 1).

The survey area is located in a low-lying (100 – 200 m above S.L.) fairly flat, monotonous region bordered by the steep "Tambaoura Escarpment" to the east and the Faleme river plain to the southwest. The only relief is made by laterite plateaus and occasionally low hill of more resistant rock-types rising a few tens of meters above the surroundings. The Faleme represents the only permanent river. Its numerous tributaries are dry except during the short rainy season.

The survey area belongs to dry tropical zone. The monthly average temperature varies between 23°C and 35°C. During the dry season maximum temperature may occasionally exceed 45°C. Rainfall is concentrated in the short rainy season (June ~ September), and is usually in excess of 1000 mm. Vegetation is poorly developed, and is essentially composed of thorn-bush, bamboos and frequent baobabs.

The subsurface soil is a lateritic residual soil and its weathered depth is about 70 m considering the height of termitaria(1-3 m).

The survey area is underlain within the Kenieba inlier, composed of Birimian rocks (lower Proterozoic) surrounded by upper Proterozoic and Paleozoic formations. The Kenieba inlier, roughly triangular in shape, extends for a distance of about 200 km in a N-S direction with maximum width of 150 km near the Senegal-Guinea border. The inlier is almost entirely composed of Birimian sediments and/or volcanics and young granitoids and mafic intrusions. The brief geologic map of the survey area (Goossens, 1989) is shown in Figure 2.

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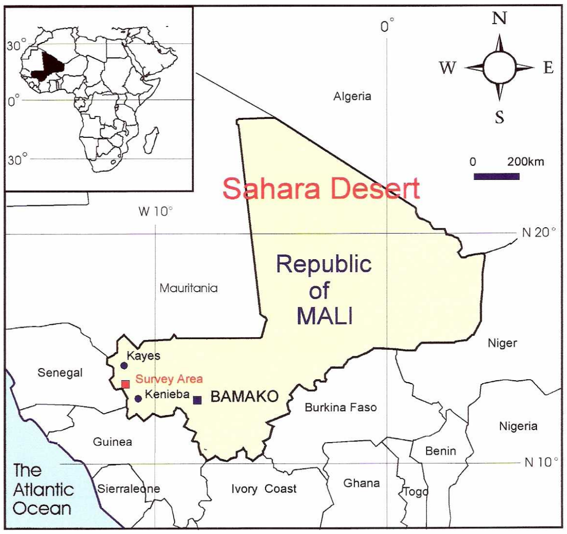

Figure 1: Location map of the survey area in Mali.

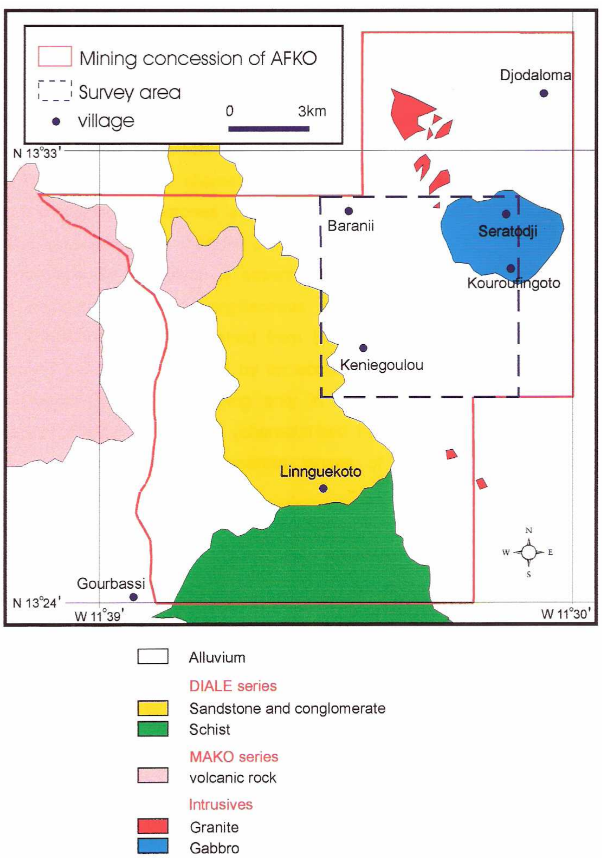

Figure 2: Geologic map of the survey area.

Four major lithologic units in this area are as follows; the Mako Series, the Centrale Series, the Kenieba Series, and the Detritic Series.

The above four Series are tightly folded around N-NE trending axes, and are dipping usually steep. They are affected by regional low grade metamorphism. There are two main regional fracture directions: N-S and ENE. Granite, diorite and gabbro intrusions are numerous, and show a various age. The dominant intrusives of granitic bodies are associated with the Eburnian tectonics (1900 ~ 1800 Ma).

Gold mineralization

Gold has been produced from alluvial placer, eluvial placer and primary gold-bearing quartz veins. Currently gold is mainly produced from alluvial and eluvial placers.

Alluvial placers are composed of argillaceous fine conglomerate bed and non-argillaceous coarse conglomerate bed. Placer gold occurs in almost all paleochannel in the Brimian formations, and is localized in paleofluvial sediments and conglomerate bed of paleofloodplain.

Eluvial placer was formed from the decomposition or disintegration of rock in place. In section view, it looks like the head of mushroom on bed rock.

Primary gold-bearing quartz veins have been known as the source of Au, and are currently the exploration target for Au deposits. Occasionally, quartz veins with the maximum width of more than 0.5 m were observed on the outcrops of schist and sandstone.

SAMPLING AND CHEMICAL ANALYSIS

The preliminary field survey was carried out for 15 days from 25th March to 8th April, 1996. The reconnaissance survey was undertaken over an area of 50 km2 for 41 days from 24th April to 3rd June, 1996. A total of 2,597 soil samples were collected using the grid patterns of 200 m by 100 m. From the reconnaissance geochemical survey for Au and As, an area of 10 km2 was selected for the detailed geochemical survey. The detailed survey covering over an area of 10 km2 was carried out for 50 days from 21st October to 9th December, 1996. A total of 2,146 soil samples were taken using the grid patterns of 200 m 25 m, and 80 termitaria samples were also collected. All soil samples were sent to PDRM (Programme pour le Development des Resources Minerals) located in Bamako, the capital of Mali, for the analysis of Au and As.

All samples were dried in the sun and sieved to -10 mesh. After drying at 105°C for 24 to 48 hours, they were disaggregated in a mortar and sieved for -80 mesh fraction. Samples were analyzed for Au by using MIBK-GFAAS (Graphite Furnace Atomic Absorption Spectrophotometry) after digestion of 10 g samples with aqua regia. The analytical range is in 5 ~ 500 ppb, and the analytical detection limit is 5 ppb. The samples containing over 500 ppb Au were analyzed using air-acetylene flame AAS, and the analytical detection limit is 20 ppb. Analysis for As was carried out by using hydride generation-AAS after digestion of 0.25 g samples with aqua regia followed by the reduction with potassium iodide. The analytical detection limit of As is 2 ppm.

INTERPRETATION OF GEOCHEMICAL DATA

Statistics of data

Among 2,597 soil samples which were collected during the reconnaissance survey, the number of samples over the detection limit for Au and As is 812 (31.3%) and 2,218 (85.4%), respectively. The statistics for Au were calculated except for 79 samples which have a questionable Au content. Therefore, the number of sample over the detection limit for Au is 737 (29.3%). The median of Au and As are 10 ppb and 11 ppm, and the standard deviation of Au and As is 115 ppb and 27 ppm, respectively.

For the detailed survey, the number of soil samples containing over the detection limit for Au and As is 523 (24.4%) and 1,932 (90.0%), respectively. The median of Au and As is 17 ppb and 11 ppm,and the standard deviation of Au and As is 147 ppb and 24 ppm, respectively. In termitaria samples, the number of samples over the detection limit for Au and As is 45 (56.3%) and 77 (96.3%), respectively. The median of Au and As is 15 ppb and 12 ppm, and the standard deviation of Au and As is 66 ppb and 16 ppm, respectively. The number of soil samples having less than 5 ppb Au (analytical detection limit) is 3,404 (73.0%) among the total of 4,664 soil samples which were collected during the reconnaissance and detailed surveys.

The analytical results of soil and termitaria samples are shown in Table 1.

Table 1. Summary statistics of Au and As in soil and termitaria.

Elements	Au (ppb)		As (ppm)	
Sample (Number of samples)	soil (4,664)	termitaria (80)	soil (4,743)	termitaria (80)
Mean	41	42	19	17
Minimum	5	5	2	2
25^{th} percentile	7	8	6	6
Median	12	15	11	12
75^{th} percentile	32	51	22	23
Maximum	2,490	335	325	90
SD	129	66	25	16
CV(%)	3.17	1.57	1.37	0.96

* SD (standard deviation) and CV (coefficient of variation)

Distribution patterns of Au and As

The reconnaissance survey

Contour maps are plotted using kriging as a gridding method, and presented with the four groups of less than M, M ~ M+SD, M+SD ~ M+2SD, and more than M+2SD (M, average

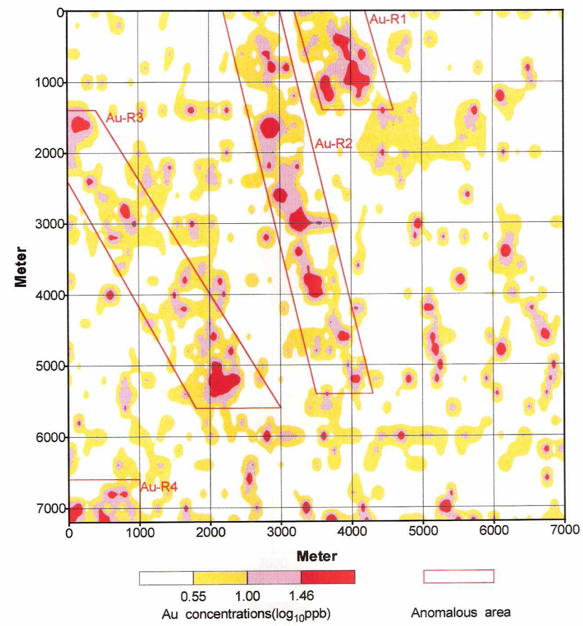

Figure 3: Contour map of log-transformed Au concentration in soil for the reconnaissance survey

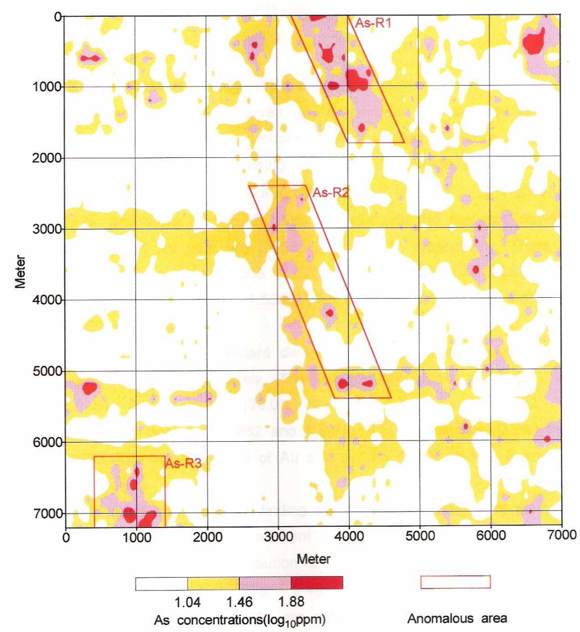

Figure 4: Contour map of log-transformed As concentration in soil for the reconnaissance survey.

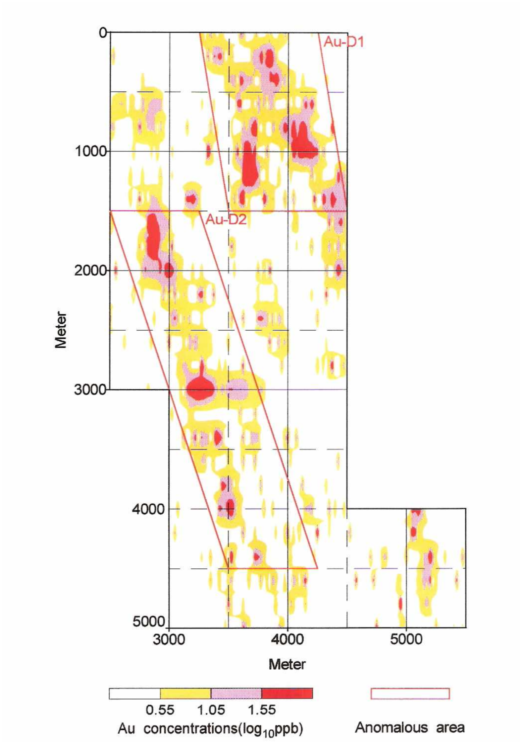

Figure 5: Contour map of log-transformed Au concentration in soil for the detailed survey.

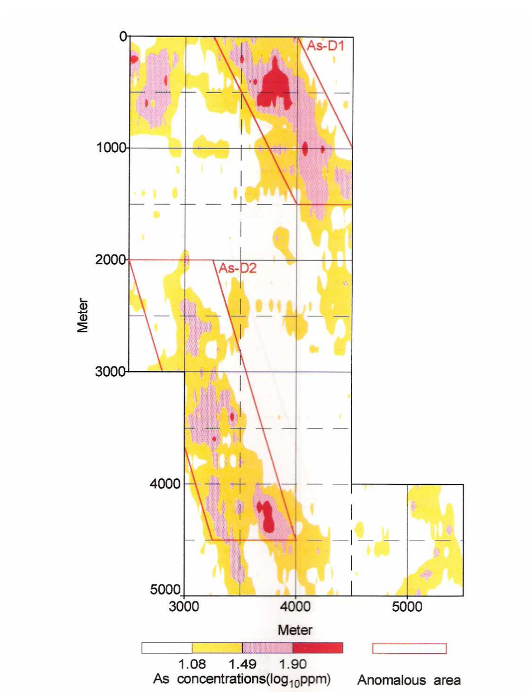

Figure 6: Contour map of log-transformed As concentration in soil for the detailed survey.

value, and SD, standard deviation) of log-transformed Au and As data.

The contour maps of Au and As are represented in Figure 3 and Fig 4, respectively. Although the correlation between Au and As is very low, anomalous areas of Au and As show similar distribution patterns.

Four Au anomalous areas of Au-R1, Au-R2, Au-R3, and Au-R4 (Figure 3), and three As anomalous areas of As-R1, As-R2, and As-R3 (Figure 4) were selected from this stage. The anomalous areas of Au-R1 and As-R1, Au-R2 and As-R2, and Au-R3 show similar directional patterns with the main regional fracture direction (NS). The area of Au-R1 and As-R1, and Au-R2 and As-R2 are localized in tourmaline sandstones reported in Goossens (1989). The areas of Au-R1 and As-R1 coincide with the presence of quartz veins which were found on the ground surface during the reconnaissance survey, and those of Au-R2 and As-R2 coincide with fault zone. An area of 10 km2 covering the Au-R1 and As-R1, and Au-R2 and As-R2 anomalies was finally selected for the detailed geochemical survey.

The detailed survey

Contour maps are plotted by using the same method of the reconnaissance survey. The contour maps of Au and As are shown in Figure 5 and Figure 6, respectively.

Considering contour maps, two Au anomalous areas of Au-D1 and Au-D2 (Figure 5), and two As anomalous areas of As-D1 and As-D2 (Figure 6) were finally proposed as promising prospects for Au occurrences. The proposed areas coincide with the results of the reconnaissance geochemical survey.

Termitaria are composed of materials derived from lower soil horizons. In areas with thicker allochthonous soil cover, termitaria are an effective media for gold exploration (Gleeson and Poulin, 1989). In general, Au content of termitaria is high in soils having high Au. In particular, Au content of termitaria in the Au-D1 and Au-D2 anomalous areas is higher than that in the other areas. Arsenic content of termitaria in the As-D1 anomalous area is also higher than that in the other areas. Because the upper portions of termitaria represent the characteristics of lower soil horizons, it is necessary to survey the subsurface of the termitaria site with high Au in order to identify the source of Au.

CONCLUSION

The promising areas for gold occurrences were proposed from the contour maps of Au and As in soil and termitaria. Four Au anomalous areas and three As anomalous areas were selected from the reconnaissance survey and the areas show similar directional patterns with the NS direction of the main regional fractures. From the detailed survey, each two anomalous areas of Au and As were finally proposed as promising prospects for Au occurrences.

It is difficult to identify parent source rocks and to observe outcrops because the survey area has been weathered intensively. Therefore, it is impossible to clarify the type of Au deposits and the source of geochemical anomalies. We recommend regional geological survey by systematic boring and prospecting under the subsurface of the proposed promising areas for gold occurrences.

REFERENCES

Gleeson, C.F. and Poulin, R., 1989, Gold exploration in Niger using soils and termitaria: J. Geochem. Exploa., v.31, p.253-283.

Goossens & Associates Bureau of Geological Consultants, 1989, West Mali/Dialafara gold exploration project (final report).