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Gold in Plants - An Appropriate Sample Medium for Gold Exploration in Regolith Dominated Terrains

Arhin, E.[1]

1.University for Development Studies, Faculty of Applied Sciences, Department of Earth and Environmental Sciences, P. O. Box 24, Navrongo, Ghana

ABSTRACT

Many indigenous plants have the ability to take up gold and other elements from the materials overlying the bedrock and the associated mineralized bodies. Considering the prevalence of water and oxygen in this environment, enhancing weathering and controlling most of the surface processes, the geochemical expressions of gold in the surface environments may necessarily not represent the sample environments due to regolith and landscape evolution processes. The accounts of the past and present climatic changes coupled with variable geomorphic changes suggest a mix of geochemical expressions is likely to be obtained at regolith-dominated terrains. The implications are that the unconsolidated regolith materials and secondary cemented regolith units in the form of laterites may have gold expressions in them either relating to, or not related to, the underlying bedrock and mineralization. The lack of understanding the complex regolith environments exacerbates the challenges in geochemical data interpretations, as real and false anomalies are difficult to be distinguished easily. Therefore, in detecting hidden gold anomalies concealed in the regolith at Pelangio Gold Mamfo project area, bark of indigenous deep-seated plants were sampled from three prospects: Pokukrom, Nfante and Subriso. Fifty plant samples were collected from the three prospects. The samples were oven dried at 105^{o}C for 24 hours and were later ground to <125 µm for ME-VEG41A analysis at ALS-Chemex Geochemical laboratory. Results of gold concentrations in the plant samples were analyzed and interpreted to define hidden gold anomalous areas. The gold-rich areas with concealed gold were detected in the plant sample, whilst the gold-poor environments showed subtle and low or no gold enrichments in plant samples. The study concluded that biogeochemistry in mineral exploration, particularly in areas under cover, is practically feasible and as an additional geochemical database derived from bark sample gold results can support soil surveys to define the anomalies related to hidden mineralization.

INTRODUCTION

Weathering history complexities in many terrains impact on geochemical parameters used to detect mineral anomalies in surface soils. Plants with deep tap roots are able to penetrate beyond the complex regolith into the weathered materials and hence uptake signatures of the underlying minerals which are hosted in several parts of the tree (Girling and Peterson, 1980; Erdman and Olson, 1985). Deeply weathered profiles in the tropics commonly appear ferruginous towards the surface, although in places are buried by transported overburden, and are widespread in the Sefwi-Bibiani Birimian Belts where the study was conducted. The rapid changes of the regolith and landscapes are as a result of weathering and variable geomorphic history reported in both the past and present events. These evolutional events in the surface environments have contributed to the formation of simple and complex regolith environments. Where the weathering history is simple the resultant regolith is considered simple with the associated geochemical expressions in surface samples relating generally to the underlying mineralization, but become complicated with terrains characterized by complex weathering histories or complex regolith. Therefore, to obtain samples for gold analysis beyond the limits of the complex regolith without prior understanding of the surface environment requires residual samples whose source is from a deeper environment and has not been modified by surface processes. Affam and Arhin (2005), Arhin and Nude (2010) and Arhin et al. (2015) report the use of termiteria samples to detect hidden anomalies in areas under cover, as the source materials of the termiteria are deep-seated burrowed materials transported to the surface environments by termites. This investigation seeks to use another biological material in mineral exploration in the delineation of concealed gold anomalies in areas under cover. The crux of this investigation is hinged on the theory that plants absorb micro-nutrients and minerals from deep-seated environments. These mechanisms of mineral uptake by plants extend beyond the complex regolith into the residual weathered materials as well as the mineralized body. The gold in plants expressed in the different parts of the tree, including the barks and shoots, are assumed to come from deeper regolith materials and represent undisturbed *in situ* weathered materials. Results from plant samples collected in complex regolith-dominated areas will represent real, true and residual anomalies and will reduce the challenges of interpreting geochemical data. This paper, therefore, demonstrates the use of biogeochemistry in gold exploration at Mamfo Gold project in southern Ghana.

Location of Study Area

The study area is located in southwest Ghana, close to Newmont Ahafo and Kinross Chirano gold deposits. It is approximately 75 kilometres west-northwest of Kumasi, the second largest city in Ghana and approximately 270 kilometres northwest of Accra, the capital of Ghana (Figure 1).

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Figure 1: Location of the study area in red.

Local Geology

Geologically the investigated area is located along the eastern edge of the Paleoproterozoic Sefwi-Bibiani Birimian Belt. Along this contact, the belt is dominated by basalt and dolerite, with lesser gabbro, tonalite and diorite (Kesse, 1985). However the geology of the local investigated area is underlain primarily by mafic metavolcanic, metasedimentary and volcanoclastic rocks and granitoids, which are significantly simplified on the regional geological map of Ghana (Hirdes et al., 1996). A major north-northeast–striking fault corridor, approximately three kilometres wide, traverses the east side of the study area (Leube et al., 1990). This fault corridor serves as the regional contact between the greenstone volcano-sedimentary package to the west and a regional synvolcanic intrusive to the east (Allibone et al., 2004). Common mineralization and structural features found at some places, particularly in the greenstone volcano-sedimentary rocks, are wide zones of fracture-controlled quartz-sericite-carbonate-pyrite alteration overprinting an earlier phase of hematite alteration that are hosted typically in sheared and locally brecciated, altered granitoids and to a lesser extent brecciated hematite-altered mafic metavolcanic rocks.

Uptake of Gold by Roots to Plant Barks and Shoots

Girling and Peterson's (1980) work suggest plant roots have an ability to take up gold from soils and accumulate them in several parts of the plant. It is possible that plant secretions from the root systems aid the uptake of gold from the soil and that cyanide in some plants, in particular, render gold sufficiently soluble to enable plants to accumulate the metal. Plants that release cyanides are referred to as hyperaccumulators and those unable to release cyanides are non-hyperaccumulators. Trees sampled in this study were not investigated to determine which of the two classes the trees fall into, because the study was just an exploratory survey aimed to define hidden gold anomalies. This needs to be investigated in future research. However, cyanogenic plant species are known to produce free cyanide by hydrolysis of cyanogenic glycosides within their tissues (Girling and Peterson, 1980). This process allows many of the plants to transport gold upwards via the macerated tissues of plants. In addition to that, there are other mechanisms of gold uptake from underlying mineralization in the regolith to the plants, and these depend on chemical factors in the regolith profile or weathered profile. The gold in the soils form compounds with either chloride or cyanide and are taken up as soluble gold by the plant roots (Lintern et al., 2013). The soluble gold species transported by the roots often accumulate in the plant shoots and are not present in the nutrient solution, as the plants do not need gold in their food preparation. Considering this to be the fact then gold in plants are absorbed gold and will represent residual gold devoid of nugget effect and free from contaminations.

METHODOLOGY

Fifty plant or vegetation samples were collected. Nine samples were collected from Pokukrom West, 13 from Nfante East and 25 from Subriso Main. To avoid adsorbed gold contaminating the samples, the outer skin of the part to be sampled was scraped and a fresh sample collected from the nearest fibrous plant tissue (Figure 2).

Figure 2: Scraped and sampled sections of tree for bark sampling

The collected samples were oven dry at 105°C, ground to powder and sieved to < 125 µm size fraction at the University for Development Studies, Multi-Purpose Laboratory. The sieved samples of 100 g weight were sent to ALS commercial laboratory in Kumasi for ME-VEG41A analysis that uses ICP-MS technique. Method precision of ± 10–15% on super trace multi-element analysis on ashed vegetation samples determined via aqua regia digestion and ICP-AES and ICP-MS analysis were measured and recorded for the samples. Detection limit for gold is 0.0002 ppm.

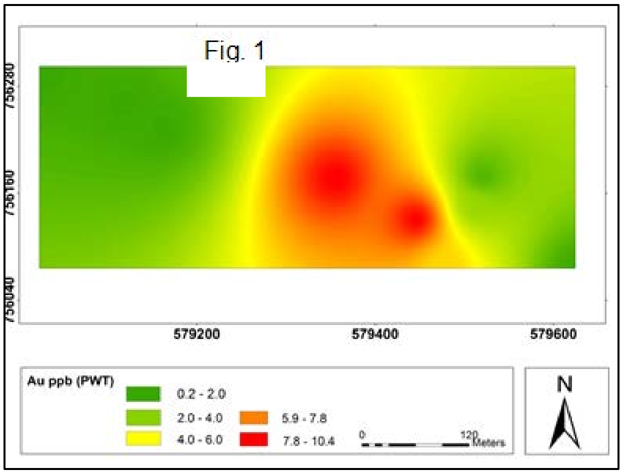

Figure 3: Gold in plants at Pokukrom Prospect.

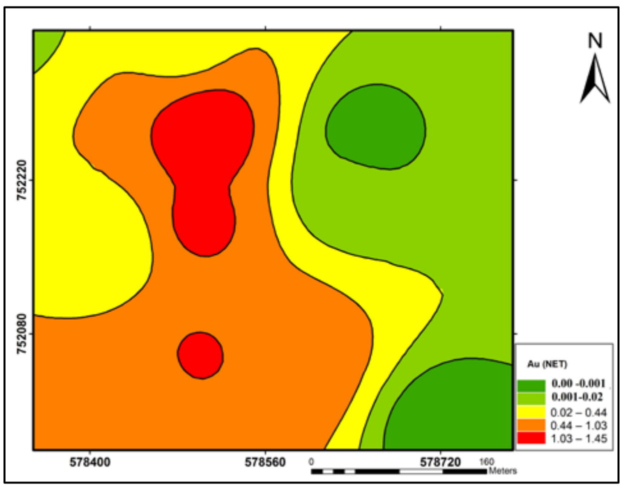

Figure 4: Gold in plants at Nfante Prospect.

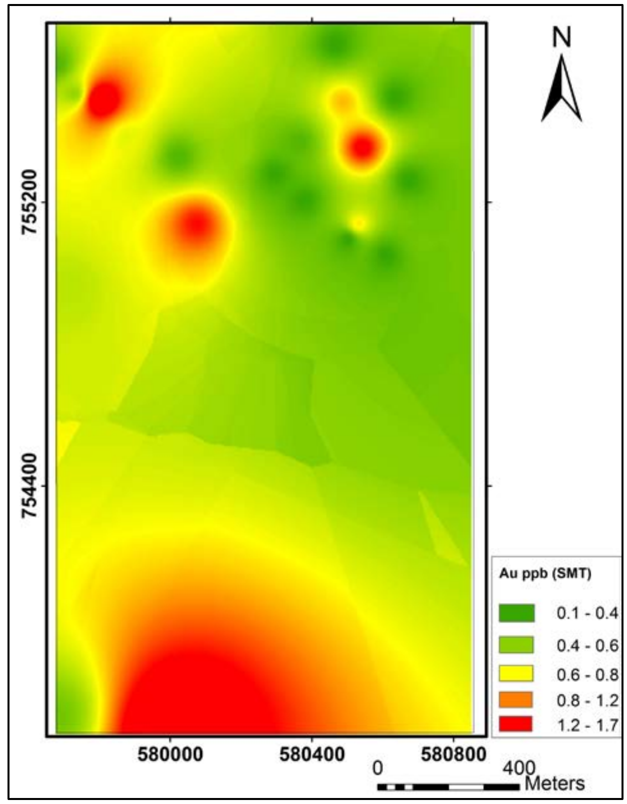

Figure 5: Gold in plants at Subriso Prospect.

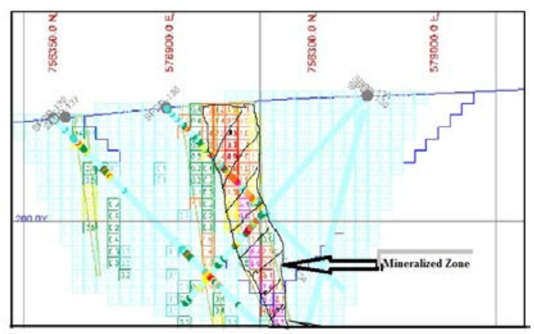

Figure 6: Hidden mineralization at Pokukrom Prospect redefined from plant bark samples.

RESULTS AND DISCUSSION

Geochemical gold expressions in tree bark samples, though low and realistic with respect to landscape locations, delineated hidden gold anomalies in areas where conventional soils failed. The geospatial geochemical signatures in vegetation samples for the selected areas are presented in Figures 3–5.

The gold expressions in tree barks sampled at Pokukrom West returned significant gold values particularly in areas with bedrock mineralization (Figure 6), which decayed away from the source orebody.

The gold anomalous area defined by tree bark samples at Pokukrom West target coincided in places with drill holes having good interceptions with bedrock mineralization. The coincidence and confirmation of biogeochemical samples from tree barks defining the hidden anomaly demonstrated the uptake of gold at depth by tree roots even though the biotic mechanisms of gold migration are poorly understood. The gold geochemical results from this study suggest and reaffirm the knowledge that gold can accumulate in plants. Furthermore, as confirmed at Pokukrom, tree bark sample results demonstrate biogeochemical absorption of gold by tree roots from the underlying gold mineralization beyond the complex regolith. So the gold in the tree bark may be an absorbed gold in solution translocated to other parts of the plant via the root system. Plants in the process of obtaining nutrients for its growth take up gold, which is considered probably toxic to plants, and in so doing expel or move the contained gold absorbed by the plant roots to its extremities (Girling and Peterson, 1980) (such as leaves) or in preferential zones (Gardea-Torresdey et al., 2002) within cells in order to reduce deleterious biochemical reactions. As seen in Figure 2, bark of trees sampled did not include the outermost skins of the plant where adsorbed gold may tend to reside, as they were scraped off until the inner fibrous tissue of the plant is reached. The portions collected as samples can be said to be devoid of gold particles adsorbing onto the plant surfaces, and thus any incidence of aeolian contamination is ruled out. The 50 plant samples collected at different target areas with different styles of soil anomalies returned variable gold geochemical anomalies reflecting the conditions of the underlying mineralization (Figures 3–5). Plants close to concealed mineralization returned significant gold values after ICP-MS analysis using ME-VEG41A technique developed by ALS-Chemex. Tree bark samples located away from hidden mineralization had insignificant and subtle assay results (Figures 3–5). Plots of these results show clearly where the hidden gold is located in an area considered not to host any gold when surface soil samples were used as a geochemical exploration tool to detect gold anomalies.

CONCLUSIONS

Vegetation samples are able to detect hidden gold deposits. Elevated gold values in tree bark in the area of the Pokukrom Prospect that has been drilled and proven to have gold mineralization reflect the presence of this mineralization. Results of vegetation sampling also defined several isolated anomalous targets in the Subriso area, yet to be infilled and trenched, and revealed the gold prospectivity of Nfante area which hitherto was considered as a no-gold terrain in the concession. Sapele trees sampled in the area can penetrate the sub-surface up to 75 m and should be seen as a poor-man's drill hole to bring residual materials to surface. In conclusion, by understanding the regolith environment and applying biogeochemical surveys (plant or termiteria sampling) hidden anomalies under cover can be detected.

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