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LATERITE SAMPLING PREPARATION FOR GOLD EXPLORATION SURVEY AT WESTERN BURKINA FASO, NORTHERN EXTENSION OF THE LAWRA BELT

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ABSTRACT

Laterite samples were divided into three and each sample was prepared differently for Au analysis using FA-AAS. The sample-type was identified based on the preparation end-material. The laterite sub sample types were field sample-sieved, field sample crushed and raw field sample-unprocessed. The Au analysis on these sub-samples showed 67% of the field sieved samples from the entire laterite samples had significant Au assays, 25% for the crushed field samples, 8% of both sieved and crushed samples had equal Au geochemical levels from KSG 009 samples. The raw field samples unprocessed returned insignificant Au assays. The study found field sieved samples of < 125 um size fraction to be the best sample preparation method for laterite samples and conclude that it should be employed to detect concealed Au mineralization in laterite capping terrains in the savannah regions.

Keywords: Koper, Lawra, Laterite, Gold, Sub-sample, Assay.

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Contribution/ Originality

This study is one of very few studies which have investigated the appropriate sample preparation methods on laterite samples in gold exploration in Ghana and Burkina Faso of West Africa. The protocol devised in the study is convenient for all laterite types.

1. INTRODUCTION

Replication of successful gold exploration in areas of homogeneous soils relating geochemically to underlying rocks and mineralization has not yet been identified in deep

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weathered terrains with extensive cover of ferruginous materials and vast exotic sediments. But as geochemical exploration for gold has made significant discoveries in areas of sub crop and outcrop it appears the east to find gold deposit have all been discovered (Butt and Zeegers, 1992). but the recent decline new discoveries has resulted in shift attention to poorly exposed parts of the savannah regions, which are covered by thick and extensive laterite and redistributed sediments for gold exploration surveys. The problem of detecting anomalies in laterites in the savannah regions is exacerbated because there has not been any laterite geochemical mapping in this region to establish geochemical background to help identify and delineate broad geochemical trends. Elsewhere in the world particularly in Australia sampling ferruginous materials had assisted in the discovery of gold under cover example Boddington gold (Au) (Anand, 2001). The advances in laterite geochemistry have resulted in critical approaches for the interpretation of anomalies in laterite samples. Despite the subtle and high gold signature expressions in the ferruginous laterite which may represent residual and transported anomalies as the formation of laterite can occur both in relict and depositional regime (Anand *et al.*, 1993) they have acquired knowledge which allow them to distinguish regional geochemical patterns from geochemical signatures of targeted mineralization in lateritic residuum (Anand *et al.*, 1993; Anand, 1994; Cornelius *et al.*, 2001). Contrastingly in the savannah region of Ghana preparing the laterite sample for the application for the appropriate analytical method is a problem because companies still carry on gold analysis on crushed and raw field samples. Determining background signatures of laterite to allow the delineation of the target element signature needs to be done when an appropriate sample preparation method is available. Based on the successes of laterite geochemistry in discovering concealed mineralization in areas under cover; this paper uses gold values obtained from laterite samples analysed for gold in raw field samples, field samples-crushed to 70% of materials passing -2 mm mesh and field samples-sieved to <125 μm to determine which portion yields best results for anomaly delineation.

2. LOCATION, GEOLOGY, REGOLITH AND PHYSIOGRAPHY

2.1. Location and Geology

Koper is the study area, located in Western Burkina Faso, 263 km SW of Ouagadougou, the capital of Burkina Faso, along a National Highway to a town called Dissin and about 25 km northwest of Hamile in the Lawra belt of Ghana (Fig. 1). The underlain rocks are metasedimentary rocks consisting of black Shales, Phyllite, Schist, tuffaceous Phyllite and Tuff (Fig. 1). General trend of the rocks are northerly and dips between 054-065° but there are some that dips vertically.

2.2. Regolith of the Area

Regolith is used as a general term for the entire cover; unconsolidated or cemented that overlies coherent bedrock. The regolith of Koper has patchy relict and erosional zones but extensive ferruginous areas. These areas are overlain by younger sediments that may themselves be weathered validating Anand and Butt (1998) report made for some landscapes in the Yilgarn Craton of Australia.

The area is characterised by composite profile (Fig. 2) and compound profile (Fig. 3). Commonly found in the area is the composite profile where the pre-existing and preserved surfaces have been part or fully eroded and are covered by ferruginous sediments and ferricrete. This regolith profile hides and hosts metal anomalies particularly Au in ferruginous materials and is the first sample medium to be collected during geochemical surveys because of their common presence here. Properly preparing the samples for chemical analysis is vital as some metals may be sorped in Fe-oxide nodules whilst others may concentrate in the matrix units. Traditionally surface samples are sieved to < 125 μm whilst the coarser units are discarded (Griffis *et al.*, 2002).

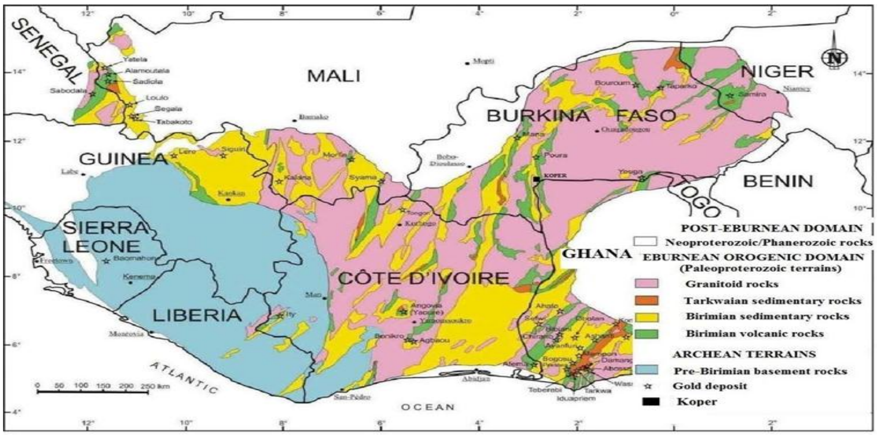

Fig-1. Location and regional geology of the study area (Milési *et al.*, 2004)

There are chances that the coated detrital or coarse grains discarded during sieving would be Au-rich and may impact on the true geochemical expression in that environment. Maybe crushing the field samples or analysing the metal content from the raw field samples without any sample preparation will yield better geochemical results; all these need to be compared to ascertain the best sample preparation method for this type of media.

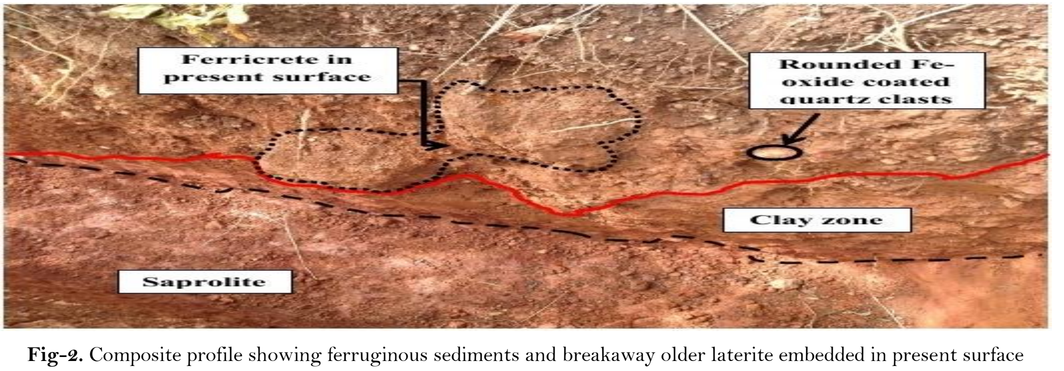

Fig-2. Composite profile showing ferruginous sediments and breakaway older laterite embedded in present surface

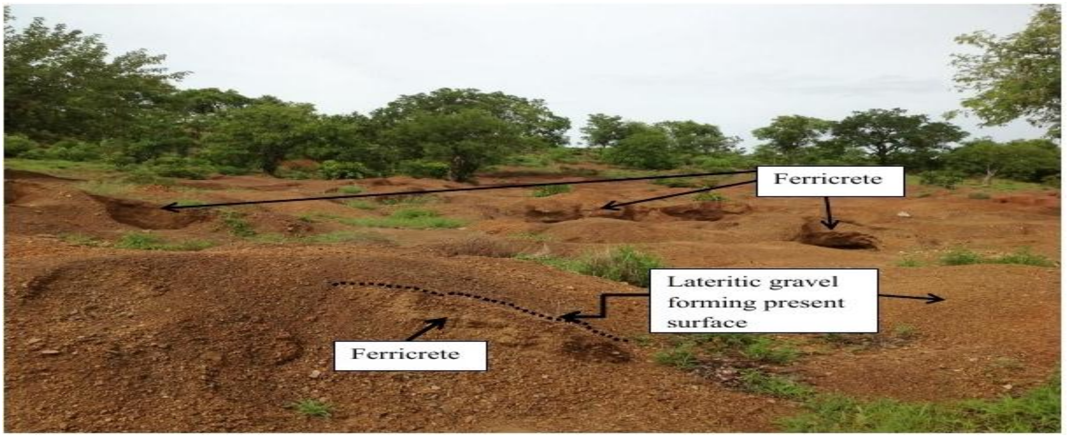

Fig-3. Compound profile depicting transported laterite terrain. Lateritic gravels overlying ferricrete as a result of episodic deposit of sediments.

2.3. Physiography

Koper is characterised primarily by tropical savannah climate with two very distinct rainy and dry seasons. The annual rainy season receives between 600 and 900 millimetres (23.6 and 35.4 inches) of rainfall; whilst temperatures ranging from 25–47 degrees C with hot, dry wind from the Sahara, called harmattan characterised the season. The rainy season lasts approximately four months, May/June to September. Koper area typical receives more than 900 mm (35.4 in) of rain each year and has cooler average temperatures compared to the northern part of Burkina Faso.

3. GENESIS OF FERRUGINOUS MATERIALS AND THEIR USE AS SAMPLE MEDIA

Lateritic residuum forms the upper part of complete lateritic weathering profiles (Fig. 4). This comprises lateritic duricrust and/or loose nodules and pisolithic soils. The duricrust forms through ferruginization and residual accumulation of mainly Fe oxides and silica in the upper part of the residual regolith. Duricrust or lateritic residuum generally occupies low rises, crests and mesas but these are uncommon in the study area. On the contrary ferruginous materials occupying the present surfaces of highlands, low rises, crest of ridges and mesas are formed from cementation of redistributed sediments from diverse sources. Loose lateritic gravels and pisoliths are widespread and had form lags on truncated and pre-existing preserved relict surfaces. The ferruginous lag represents the remnants of a range of Fe-rich regolith materials (Anand, 2001). The nature of the lag reflects the type of the upper regolith and varies according to amount of erosion and landscape position. From the perspective of ferruginous lag formation, composition can range from yellowish-brown goethite–kaolinite-rich fragments of mottled saprolite to fragments of ferruginous duricrust on hill crests and upper slopes, to reddish brown to brown hematite– goethite–kaolinite nodules and pisoliths with cutans or skins and black hematite–

maghemite-rich pisoliths without cutans on upper to lower back-slopes, and polymictic lag on depositional plains. The ferruginous lags are present in both residual and depositional regimes but are more common on residual ferruginous material, transported material and ferricrete. The dominance of lag at Koper may be attributed to the intense wind that blows during the harmattan dry season and contribution of sheet wash during flash floods during the short rainy season. These two processes contribute to the removal of fines in the surface environment leaving the lag materials behind.

Fig-4. Example of lateritic residuum in the area

Disintegration of the ferruginous lag materials showed variable textures and compositions. Their components are derived from erosion of pre-existing lateritic residuum, ferruginous saprolite and saprolite as noticed by Anand (1998) in his work at the Yilgarn Craton in Australia. They can overlie lateritic residuum, saprolite, or other transported material. Sampling the ferruginous materials is possible to detect regional anomalies especially for Au because most regional geochemical sampling programs cover a variety of terrains and regolith settings with a diverse suite of ferruginous materials. But the true representation of the contained metal will depend on how the sample is processed for geochemical analysis. Testaments from Smith *et al.* (1992); Anand *et al.* (1993); Anand (2001) show the effectiveness and usefulness of ferruginous materials as sampling media to detect dispersion haloes from Au and base metal deposits in the regolith. Gold and some elements become closely associated with secondary Fe oxides, the main components of ferruginous materials (Smith *et al.*, 1992; Anand *et al.*, 1993; Anand, 2001). It is imperative to devise an appropriate sample preparation protocol that yields more representative assay results for ferruginous samples because of their widespread spatial distribution. For instance lateritic gravels, in particular pisoliths, can move down slope and transport resistant minerals and elements retained within them. Apparently at flat-dominated terrains, lateral transport can be of the order of several hundred metres and can offset a geochemical signature. With landscape and regolith modifications, residual accumulation of weathered materials that are partly cemented by Fe-oxide contributes to broadening of geochemical 'footprint' of an ore deposit or bedrock feature. As noted by Smith (2005; 2004) the textural information from the lateritic nodules and clasts in the ferruginous samples can be diagnostic to determine the type of the anomaly whether it is residual or transported anomaly. The preserved micro fabrics within the nodules and clasts may give some clues to their origin. Also the understanding of the paleo topography and probable dispersion directions can guide the interpretation of the laterite geochemical data and vectoring towards mineralization. Hence the concerns of this study to appropriately determine suitable laterite sample preparation method for regional gold exploration in the savannah region of West Africa.

4. METHODOLOGY

Laterite samples were collected from 30 cm nominal diameter-holes and this was based on significant gold results obtained from orientation surveys carried out by gold exploration companies in the area. Data appraisals of gold results particularly in non-laterite dominated terrains were appropriate for this 30 cm depth and thus were adopted to be used in this study. The excavations were made using a digging hoe. The first 20 cm was discarded as most of the area was overlain by thin soils influenced at places by humic substances. Ferruginous materials between 20cm to 40 cm depth of the excavated holes were collected as geochemical samples in this case for Au analysis. 2 kg weight sample was collected for each of the 36 sampling environment. To ascertain quality of the analytical data, quality control sample allocations of 2 duplicates, 1 certified reference material (standard) and 1 blank sample were inserted in batch of samples submitted to the laboratory. The samples were homogenised and then first divided into two portions. One of the divided samples was further divided into two which resulted into three samples. One of the first split samples was labelled after oversize materials >4 mm size fraction removal. These samples were analysed for Au and is designated in this study as raw field samples. The remaining two sample sets were prepared by sieving and crushing. Metals tend to accumulate in the fine fractions so one set of the samples were sieved to < 125 µm. The last set of samples was crushed to better than 70% of the entire sample passing through -2 mm mesh to help release any absorbed and adsorbed Au in the Fe-oxide nodules and clasts. The prepared samples were referred to field sieved and field crushed samples respectively. These three sets of samples were sent to ALS Burkina Faso for Au analysis using fire assay with AAS finish (FA-AAS). 50 g nominal weight of the readied samples were analysed for their Au content at a reporting range of 0.005-10 ppm values.

5. RESULTS

Results obtained from the laterite samples analysed using FAAS analytical technique at ALS-Chemex analytical laboratory in Ouagadougou, Burkina Faso is shown in Table 1.

Table-1. Gold assay values in the three sets of the laterite samples from Koper area.

Sample ID	Field sample-sieved	Field sample-crushed	Raw field sample
KSG 001	0.03	0.02	0.004
KSG 002	0.004	0.05	0.02
KSG 003	0.12	0.03	0.004
KSG 004	0.05	0.004	0.004
KSG 005	0.08	0.06	0.02
KSG 006	0.04	0.02	0.004
KSG 007	0.18	0.07	0.004
KSG 008	0.03	0.02	0.004
KSG 009	0.09	0.09	0.03
KSG 010	0.04	0.06	0.004
KSG 011	0.03	0.04	0.03
KSG 012	0.04	0.03	0.004

All measurement are in ppm and detection limits is <0.005

Behaviour of gold expressions in different prepared laterite samples and percentage proportions of best gold assays are presented in Figs. 5 and 6 respectively.

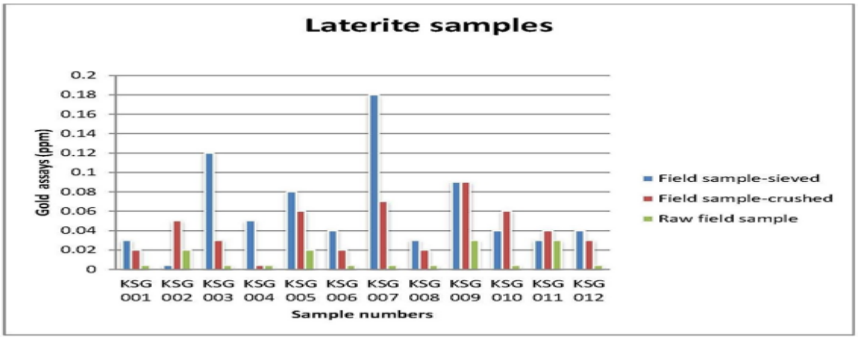

Fig-5. Comparison of Au assays in laterite samples prepared differently and analysed by FA-AAS to assess best sample preparation protocol for regional Au exploration

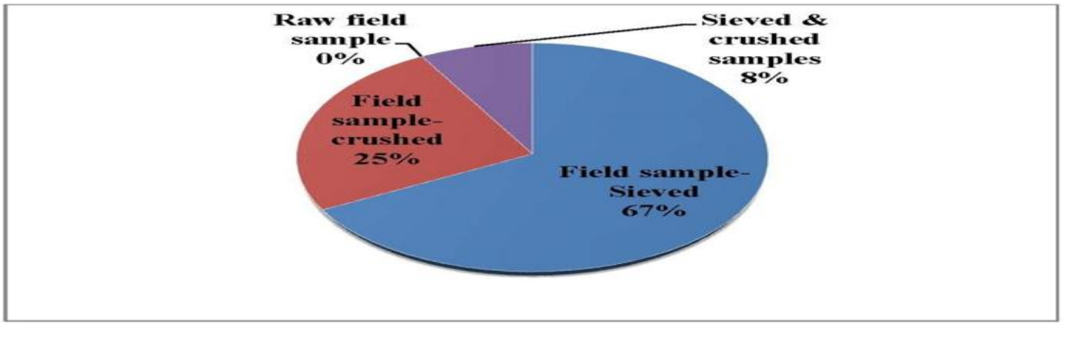

Fig-6. Percentage (%) proportions of best Au assays in different prepared samples of laterite.

Table 1 presents analytical values obtained for Au in the three sets of ferruginous material samples whilst Fig. 5 shows Au assay levels in geochemically similar samples but with different sample preparation methods. Fig. 6 represents the different prepared samples in percentages for geochemical Au exploration using laterite samples and this is based on the recoverable assay Au contents in the individual prepared samples..

6. DISCUSSIONS

As seen in Fig. 5 unequal Au assays were recorded for 34 out of 36 samples obtained from the 12 laterite sample sites. The 12 laterite samples were divided into three parts and were prepared differently for geochemical Au analysis. From Fig. 5 two sample splits from the sample labelled KSG 009 had equal Au contents both in the sieved and crushed split samples; each returned Au values of >0.08 ppm respectively. The appraisal of the data in Table 1 as presented in Fig. 6 identified the following to characterise the laterite samples based on their preparation before analysis using same FAAS test on sieved samples, crushed samples and raw field samples:

1. 67% of the fine sieved samples <125 μm size fraction recorded Au assays higher than all other samples i.e. field samples-crushed to -2 mm and the raw field samples.
2. 25% of the field crushed samples of the total samples analysed returned higher assays in samples KSG 002, KSG 10 and KSG 011.
3. 8% of sieved and crushed samples had Au assays to be the same in KSG 009 and
4. None of the raw field samples appeared higher than the other two split samples prepared either by sieving or crushing.

From Table 1and Fig. 6 it can be interpreted that direct analyses for Au in raw field samples is not appropriate to detect Au signatures in laterite. The inappropriateness could be due to the presence of coated Au-poor clasts, pisolithic and Fe-oxide nodules formed during lateritization. The presence of these secondary transformed regolith units may affect the sample weights and volumes of the raw field samples and rather reduce the proportion of fine fractions generally known to host metals. The field samples crushed to -2 mm size fraction may also be unsuitable because the crushed oversize materials may again cause dilution in the samples if the source crushed detrital material is from a barren source. However if the source of the oversize materials is from Au-rich source then significant Au concentration may be obtained.

As presented in Figs. 5 and 6 some of the field crushed samples recorded relatively higher Au assays in some samples. The source of the high assays can be local or far as reported by Anand (2001) that residual and transported laterite can form in both relict and depositional regimes. Identifying the source of high assays in the field crushed samples is to gather textural information from the lateritic nodules and clasts before crushing the samples. Also vectoring to the mineralising area will require the understanding of the paleo-topography which may probably give clues to the dispersion directions of the Au anomaly. But as seen in Fig. 6, only 25% of the entire samples analysed showed significant Au values for the field crushed samples suggesting it is not the most appropriate sample preparation approach in detecting Au anomalies from laterite samples. However in Figs. 5 and 6, 67% of the field sieved samples registered high Au assays relative to raw field samples and crushed field samples. This makes sieving the laterite samples to <125 μm size fraction the best among the three same media but different preparation methods before Au analysis. The residual accumulated minerals and elements cemented by Fe-oxides and clays and the resistant minerals and elements transported after which Fe-oxide cementation occurred after weathering and erosion may be present in the cementing matrix that may constitute the fine fractions. The relatively high Au assays obtained for the field sieved samples observed in the current study is the validation of the fact that metals tend to accumulate in the fine fractions of regolith materials.

7. CONCLUSION

To detect Au mineralization concealed in laterite as a result of some metals and elements affinity for Fe-oxide, the main cementing medium during lateritization sample preparation of laterite from Koper were analysed for their Au contents. The study analysed Au using FA-AAS analytical technique in a set of laterite samples from the same location but with different sample preparation methods. The analysis was performed on prepared laterite samples consisting of:

- Raw field samples-unsorted or unclassified
- Field samples sieved to <125 μm size fraction and
- Field samples crushed to – 2 mm mesh fraction.

The study found among the three processed laterite sample types field samples sieved to <125 μm size fraction to have significant Au geochemical signatures that can be used to detect mineralization in laterite capping environments. It therefore concludes that field laterite samples sieved to <125 μm size fraction be used in regional Au geochemical sampling in laterite dominated terrains of similar weathering and geomorphic histories.

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Competing Interests: The authors declare that they have no competing interests.

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