GUIDES TO ALLUVIAL GOLD EXPLORATION IN GHANA

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ABSTRACT

This paper, the second of our series on alluvial gold exploration in Ghana, discusses some of the causes of the failures of placer gold exploration programmes in the country that were identified in the first article.

The need to recognise and rectify the common lapses and peccadilloes displayed by Ghanaian exploration personnel is important because mining is a prime risk venture.

As the issue is not what to do but rather how best to accomplish the task, the discussion emphasizes methodology of alluvial gold exploration and offers some guidelines which, it is hoped, would assist the beginner and refresh the experienced.

KEYWORDS: *Alluvial placers, prospecting, exploration, amalgamation, riffles, bulk sampling, trial mining.*

INTRODUCTION

This paper is a follow-up of Dzigbodi-Adjimah and Arhin (1993); [1] which discusses the state of the art of alluvial gold exploration in Ghana and the presumed causes of the failure of some Ghanaian alluvial operations. Some of the common lapses identified in the first paper such as inadequate planning and haphazard execution of exploration programmes are discussed and possible solutions proposed in an attempt to redress the dearth of technical know-how which appears to characterise alluvial gold exploration in Ghana.

To circumvent the confusion often caused by the varied terminology currently employed in the classification of placer deposits, the example of Evans (1986) [2] is emulated in this paper. We thus retain stream or alluvial placers for fluvial accumulates of Macdonald (1983) [3] and deposits resulting from in situ build-up during weathering are referred to as residual placers instead of eluvial.

Placer Gold Occurrences in Ghana

Both residual and alluvial placers occur in Ghana but the alluvial types are by far the most common [4]. The Ghanaian deposits are of Recent age and are generally believed to have been derived from the concentration of the eroded products of primary Birimian and Tarkwaian gold-bearing rocks [4, 5].

In Ghana, the problem of grassroots exploration is largely resolved by the division of the country, along the Birimian-Voltaian contact, into two broad petrogenic provinces that may be referred to as the Proterozoic and Palaeozoic domains (Fig.1).

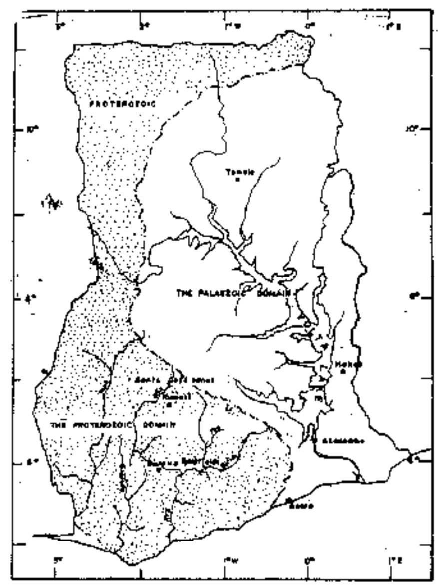

FIG. 1 THE PETROGENIC AND METALLOGENIC PROVINCES OF GHANA WITH THE ALLUVIAL GOLD MINES.

The Palaeozoic rocks occupy the northern and eastern parts of the country and comprise the Voltaian, Buem, Togo and Dahomeyan rocks. They are devoid of metallic occurrences.

The Proterozoic rocks, on the other hand, crop out at the southwestern and western parts of the country and comprise rocks of the Tarkwaian and the Birimian systems which constitute the metallogenic province of Ghana. This is the area where all mining and mineral exploration activities are

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concentrated. Within this broad province, however, the most favourable sites or "target areas" for alluvial gold concentrations are the flood plains, buried valleys, present river-beds, and the channels and terraces of the rivers listed in Table 1.

Table 1: Locations of dredgeable alluvial gold placers in Ghanaian rivers (After Kesse, 1985) [4].

RIVER	LOCALITY
1. Ankobra	From Bonsa junction 40 km upstream
2. Ankobra	Near Kotochiri between Butaboi and the Huni confluence
3. Fura	From Fura junction and Nyamiadama
4. Ofin	At Dominase
5. Ofin	16 km above Dunkwa
6. Ofin	Between Miradani and Ahiniso
7. Birim	Between Kibi and Agyapoma
8. Pra	Just below its confluence with the Ofin River
9. Jimi	Just near its confluence with the Ofin River
10. Tano	Between the Insu-Enchi motor road and Yiraboi
11. Tano	Nyankumasi
12. Tano	Nkara Disuaboi
13. Tano	Jomuro

The best known localities of alluvial gold concentrations are along the Offin, Pra, Ankobra, Mansi, Awere, Anum, Bonte, Birim and Tano river flood plains (Fig.2). Presently, three alluvial gold mines operate in Ghana; these are the Dunkwa Goldfields Limited, Goldenrae Mining Company Limited and Bonte Gold Mines. The State Gold Mining Corporation (SGMC) used to work the largest alluvial gold deposit at Dunkwa, in the Central region, with five dredges (three on the Offin, one at Subin Hill, and one on the Jimi river). Dunkwa's reserves stand at over 300 million cubic metres at the grade of 0.113 g/m^3 Au. The average depth to bedrock is 10 metres [1, 6, 7].

The total estimated reserves of Goldenrae Mining Company Limited, at the start of mining in 1991, stands at 9.0 million cubic metres at an average grade of 0.57 g/m^3 Au. This includes 5.2 million cubic metres at 0.55 g/m^3 Au at Kwabeng and 3.8 million cubic metres at 0.60 g/m^3 Au at Pameng [7]. The two locations lie respectively on the Awusu and Merepong streams that flow into the Birim river in the Eastern region. The average depth to bedrock on both lease areas is 5 metres with overburden thickness of 2 metres yielding a stripping ratio (overburden to gravel ratio) of 1: 1.25.

The Bonte Gold Mines was started in 1989 by the Canadian Gold Resources Limited on their Esaase Concession in the Ashanti region. The property stretches for 6 to 17 km along the Bonte river (a tributary of the Jimi and Offin rivers). Estimated reserves, by June 1990, stand at 4.6 million cubic metres at an average grade of 0.53 g/m^3 Au. This is made up of 2.5 million cubic metres of proven ore at the grade of 0.6 g/m^3 Au and 2.1 million cubic metres of low grade ore at 0.5 g/m^3 Au [8]. Gravel thickness varies between 4 to 5 m and the average width of the alluvial plain is 180 m. Terrace gravel overlies the auriferous gravel layer and most areas have virtually no overburden.

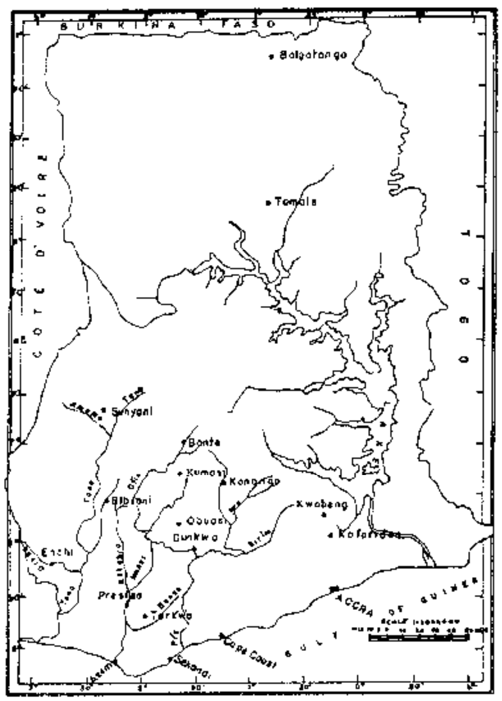

FIG. 2. MAP OF GHANA SHOWING RIVERS ASSOCIATED WITH ALLUVIAL GOLD DEPOSITS.

LAPSES IN EXPLORATION

The drawbacks to successful alluvial gold exploration in Ghana have been attributed to lapses in execution of exploration programmes [1]. The most readily identifiable source of weakness may be the methodology: How best does the explorationist carry out stream sediment sampling; execute the digging of the pits, or for instance, treat or process excavated auriferous gravel?

1) Prospecting versus Exploration

It has been observed that distinction is often not drawn between prospecting and exploration: Prospecting involves the search for an element (the value of which has not yet been made manifest) whilst exploration involves the determination of the value of the mineral content of a prospect. Since exploration is the process by which a mineral occurrence (found during prospecting) is evaluated, it should appropriately start from the end of prospecting.

During prospecting or "scouting" for alluvial gold deposits, careful attention ought to be paid to the areas most favourable for placer mineral accumulations [1, 2, 9]; always mindful of the fact that mechanical concentration rests primarily on the specific gravity contrast, size and shape of minerals as affected by the velocity of the separating and transporting fluid. Also, the lower sluggish reaches of streams are not favourable sites for placer accumulations, and neither are the upper headwaters because of limited supply of source materials.

Stream sediment sampling should be done in a systematic manner so that the results may be reproducible. The samples should be scooped from the river bed as deeply as possible near the bedrock because heavy detrital minerals, like gold, characteristically occur in greatest abundance near the base of a sequence of alluvial sediments, usually just above the surface of bedrock.

Also, a fixed volume of gravel should be treated at every location so that visual comparisons of gold concentration at the various sampling points may be made. Sampling should be concentrated at the confluences of the tributaries and should commence at the lower reaches of the main stream or river of the concession and proceed thence towards the source areas. Where positive results are obtained the process may be repeated up-stream. Further sampling along streams that have yielded negative results at their confluences is unproductive. Only a limited number of pits should be dug during prospecting.

The recommended phases for successful exploration of alluvial prospects [1, 10] are to be recognised, planned and systematically carried out. Exploration, which should also be distinguished from exploitation should commence with a preliminary phase. It appears that this initial or preliminary phase of exploration which often overlaps prospecting (with which it is generally confused) is the most improperly organised of the various stages of exploration. Preliminary exploration should concentrate on establishing the value and exploitability of the gold concentration of the prospect within broad limits. Pitting and drilling on a systematic or regular pattern are the main techniques employed in this phase.

The decision to proceed, or not, to the final phase of exploration (that is variously referred to as "close", "detail" or "main" exploration) is largely influenced by the results of the initial investigations and the exploration geologist should be able to decide the minimum grades, gravel thicknesses and areal extent of mineralization that justify the continuation of work. The final phase of exploration should be aimed at defining the orebody or deposit that can be worked at profit.

2) Pitting And Drilling

Pitting and Banka drilling are the two most widely used methods for prospecting alluvial gold deposits in Ghana. Generally, however, pitting is preferred over drilling for the following reasons:

i. Equipment for pitting is cheaper, more readily obtainable and easier to transport than drilling machines,

ii. Labour to run pitting programmes is normally unskilled, relatively cheaper and locally available,

iii. The geological information obtained from pitting is more reliable and may be easily verified by visual inspection. Also, in follow-up programmes, pits can always be re-sampled whereas for Banka drill programmes new boreholes will have to be drilled for re-sampling purposes. Furthermore, the nature of the auriferous gravels (such as presence of boulders and buried timber) is readily observed from pits.

iv. Although Banka drilling is faster and more suitable for swampy areas, volume calculations from drill holes often require empirical correlation factors which more often deal with the geometry rather than the geology of the deposits.

In exploration, the termination of pits as soon as the bedrock is reached and discarding, (during processing) of material from the top parts of bed-rock because of the usual clayey decomposed nature should be discouraged. Since the jigging action of streams usually causes heavy minerals like gold to sink into the decomposed bedrock material, evaluation studies that omit such values may seriously under-estimate the gold potential of the area. In swampy areas, exploration pits should be stabilized as discussed in [1].

Some exploration programmes employ the method of conning and quartering in routine processing of alluvial gravels. Observation shows that it is rather difficult to properly cone-and-quarter the rather large volumes of gravels often met with in the field, hence the results obtained from such practices are usually not accurate. Besides, the time taken up for the exercise may possibly be more usefully devoted to gravel washing.

3) Volume Computations

The volume of gravel treated is generally determined from calculations based on pit dimensions; the usual assumption being that the pits have a uniform cross-sectional area hence the volume of the material excavated is this uniform area, multiplied by the thickness of the gravel layer. Observation shows that exploration pits seldom have vertical sides. In hard ground the pits tend to narrow down in size with depth; trapezohedral rather than rectangular blocks are generally excavated especially where supervision is lax. Also in areas of water in-rush, silt from the sides of the pit is excavated together with the gravels. Volume calculations which do not take these factors into consideration will present inaccurate results.

4) Gravel Treatment And Gold Recovery

The size of gold grains recoverable from the alluvial gravels of Ghana ranges from 10 mm for nuggets to 50μm in fines [11] and of the methods available for recovery,

a) Jigs may recover gold sizes ranging from 10 mm to 10μm.

b) Gravity Tables are efficient within 3 mm to 100μm.

c) Sluice boxes and spirals may be used to recover gold sizes ranging from 3 mm to 250μm, and

d) Concentrators, can handle gold grains ranging from 3mm down to 50um.

Most local gold operations, however, use the traditional sluice box which is constructed from wooden boards measuring 0.30 m in width by 3.6 m in length and 0.05 m in thickness [1] to which no riffles are fitted to trap the fine gold. The estimated size of gold fines recovered by this method is much lower than the minimum expected recovery from efficient sluicing. Loss of fine gold during sluicing with the traditional box may, therefore, be quite high.

Another common cause of loss of gold is the inability of operators to maintain a regular supply of water to their washing heads. The feed to the sluice boxes is very rarely constant with the result that the feed is at times too heavy and thick leading to rapid packing of sand which steepens the gradient at the head of the sluice. This increases the velocity of water which then carries the fines off the board. At other times, the feed diminishes and the excess water, having less sand load to carry, scours the packed sand together with the liberated gold, again leading to heavy losses.

Presentation of analytical results of alluvial gold concentrates in terms of "weight of gold per tonne" should be avoided. When such values are quoted without supplying the weight of concentrate analyzed and, as it is often not possible to find the amount of gold actually present in the concentrate relative to the volume of gravel treated, these results often prove valueless in evaluating the alluvial gold deposits.

5) Bulk Sampling And Equipment Selection

Bulk sampling is a vital phase in alluvial gold exploration because it provides the opportunity for testing the accuracy of the estimated average grade, and comparing the suitability of various types of equipment for exploiting the deposit. It also furnishes useful information for feasibility studies.

Equipment selection should take into consideration the nature of the deposit, the particle size of the gold and the minimum percentage recovery needed to make the treatment profitable. Equipment suitable for treating one deposit may not be useful in relation to a different deposit when some basic characteristics of the alluvial (such as the gold grain size and its distribution in the gravels, the binding matrix, pebble and rock fragment sizes or stripping ratio) vary considerably.

A good set of equipment may not yield expected results when the expertise for operation and maintenance is absent. It is therefore necessary that every deposit be evaluated on its own merits and on the basis of capital and personnel resources that are available for working it.

DISCUSSIONS AND RECOMMENDATIONS

To summarize, it is being suggested that

1. Prospecting or scout exploration must be a fact-finding exercise. The concern of the geologist at this stage is to establish whether the concession contained alluvial gold or not. Speed and tight budgeting should prevail. Sampling of stream sediment or stream-side alluvium and noting the colours of gold may often suffice during the reconnaissance phase. Pitting may only follow if enough gold over a large enough area is indicated.

2. Ghanaian placer gold occurrences that show, at the initial stages of exploration to have grades of less than 0.1 g/m^3 Au, gravel thickness of less than 1 metre and stripping ratios of more than 2:1 (overburden thickness greater than auriferous gravel layer) should be viewed with caution.

3. Although pitting, as an exploration tool, is generally preferred to Banka drilling, the final choice should depend on the nature of the deposit and terrane. Whilst Banka drill is inadequate for exploring deposits characterized by large boulders and buried timber, it is much more effective in swampy areas where it may not be possible to pit.

4. During exploration, pitting should continue into the bedrock and in fractured zones or areas characterized by porous material such as decomposed granitic bedrock (through which gold may sink), pitting should persist for at least 0.3 m into the bedrock (as shown in Fig.3) and such material should always be treated. Different gravel layers should be treated separately and clayey bedrock should always be tested for false bottoms by probing with 2 m steel rods or "testing bars".

5. As one of the peculiarities of evaluating alluvial deposits is that cut-off limits do not depend solely on actual pay limit or mineralization but rather on the method employed in working the deposit [12], it is

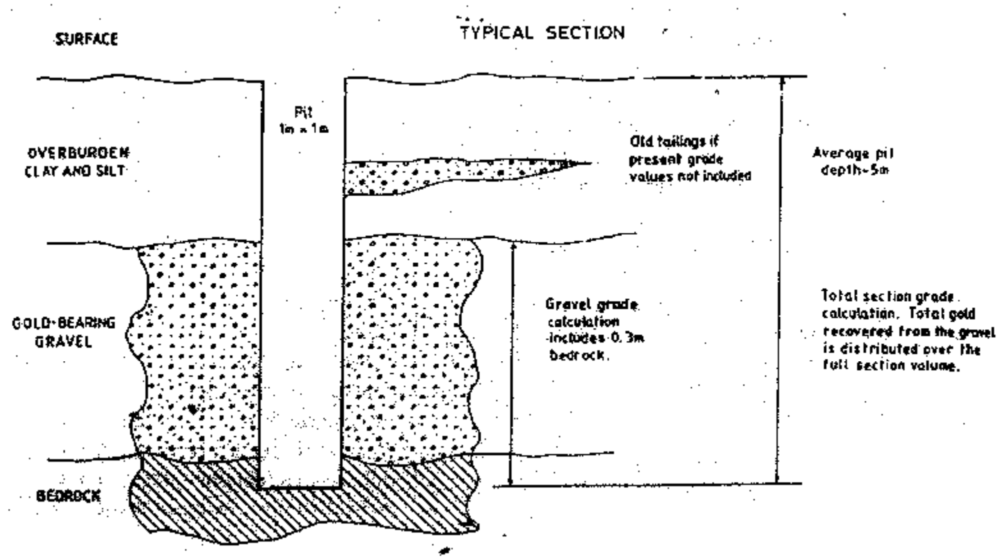

Figure 3 A TYPICAL SECTION OF A RECOMMENDED PIT.

important that information essential for evaluation and equipment selection be adequately recorded during exploration. For documentation, the records of a pit may be kept as shown in Table 2.

6. Though the method of conning and quartering may be useful in scouting or reconnaissance work, its application as a routine procedure to treat the total gravel that is excavated from exploration pits is not recommended.
If the aim of conning and quartering is to reduce the quantity of material to be panned into smaller volumes to save water, then it would be recommended that in areas where water is scarce, a composite channel sample of the gravel horizon from the four walls of the pit should rather be processed for a more reliable result.

7. Since in the actual exploitation of the alluvial gold, acid digestion or roasting process are generally not employed to liberate locked-up gold from the lattices of other minerals, processing of exploration samples should be restricted to amalgamation even though the method may give lower analytical results.

Table 2: A recommended pit data sheet

Name of Company: Supervisor:

Pit Number :

Location : Water level (from surface):

Date :

Description of Section	DEPTH (Sample Interval)			VOLUME(m^3)		RESULTS		
	From	To	Thickness	In Situ	Measured	Weight of Concentrate	No of Gold Grains	Other Precious Minerals
REMARKS				TOTAL (METERS)		GRADE		
	GRAVEL SECTION					ASSAY RESULTS		
	TOTAL SECTION					Wt. of Gold	Wt. of Diamond	Au Grade
	OVERBURDEN							
	STRIPPING RATIO							

8. Traditional sluice boxes should be improved by fitting them with riffles and\or expanded materials. Underneath the riffle system should be a form of rough and parous matting or carpet so that the gold may be trapped along the bottom edge of the sluice box. Different types of riffles are available but the "Hungarian" or "Lazy L" riffles are recommended. They do not just trap gold but concentrate the heaviest materials that are passed over them. This riffle is designed to cause a "back eddy" just behind it's upper edges (Fig.4), so that as material is fed, the back eddy sucks material down resulting in a vibratory and continuous sorting action that causes the heaviest minerals to sink and allows the lighter ones to wash

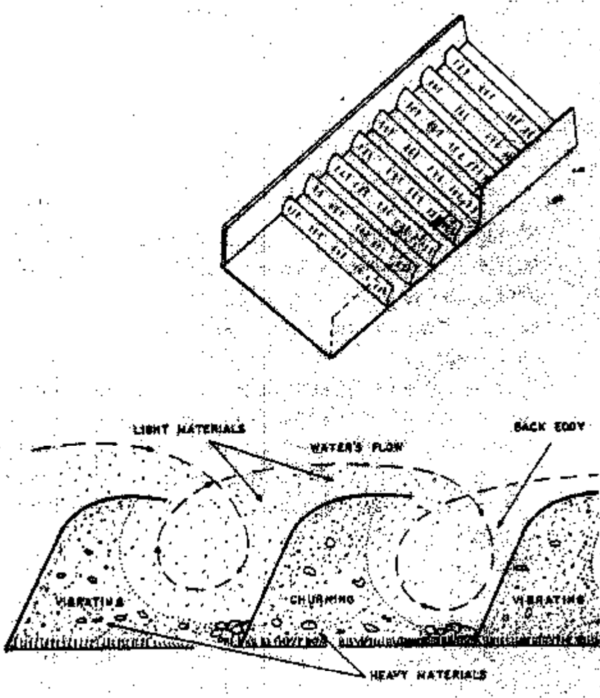

FIG. 4 HUNGARIAN TYPE RIFFLE("LAZY L RIFFLES") VIBRATING THE HEAVY MATERIALS IN AND LIGHT MATERIALS OUT

A regular and steady water velocity is an important factor in attaining maximum output during gravel treatment. Since this is dependent on the nature of material and type of sluice box, it is worthwhile experimenting with various water velocities in the field for optimum conditions. The tailings should be panned for the presence of gold. The best sluice box angle and water velocity are those that yield the least, or no gold in the tailings.

9. Minimum volumes of gravels should be proved before exploitation is contemplated, otherwise the danger exists that sufficient amounts of gravel might not be available to justify the purchase of equipment and also meet operational costs.
Adequate financial provision should also be made before mining is commenced. The hope of financing subsequent phases of exploration from the proceeds of trial mining may spell the doom of the programme.

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