THE STATE OF ALLUVIAL GOLD EXPLORATION IN GHANA

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ABSTRACT

The enactment in Ghana of Mining and Mineral Law 1986 or PNDCL 153 (Provisional National Defence Council Law 153) has led to an upsurge in the deployment of large risk capital for the search and development of gold deposits.

Of the three types of gold deposits found in Ghana (namely; primary Birimian lodes, paleoplacer Tarkwaian Banket conglomerates and Recent placers) local investors appear more interested in working the Recent placer alluvial gold because of the lower capital required for the development of the younger unconsolidated alluvial gravels as against that of the older and compact Proterozoic deposits. However, the rather modest returns on investments in alluvial gold exploration are beginning to frustrate many Ghanaian mining entrepreneurs.

The lack of adequate local technical know-how in alluvial gold exploration, poor planning and haphazard execution of programmes coupled with inadequate flow of capital are often cited as the causes of the present lack of success.

This article examines some of the reasons of these drawbacks and focuses on the methods used by two successful alluvial gold projects to serve as an archetype to both the exploration geologist and the investor. The study also advocates fortifying the law on mining to curtail the rise of mining-induced environmental degrading activities.

Keywords: Alluvial gold exploration, scout prospecting, pitting, banka drilling, pit stabilization, sluicing, "galamsey".

INTRODUCTION

The mining industry in Ghana, which had seen several vicissitudes and had been on the decline for decades, began witnessing an upsurge from 1986. This revival of mining activities, popularly referred to as the "third Gold Boom" [1,2] has seen the granting of over 70 concessions for exploration of mineral deposits. Gold appears to be the most sought for mineral during the boom and the exploration and development of both primary lode as well as alluvial gold deposits are on the increase.

Many of the new companies are joint venture operations involving local capital and international or multinational corporations like Sikaman Resources of Canada, Billiton International Metals of the Netherlands, and the International Finance Corporation, Pioneer Group Incorporated (USA), Glencar Exploration (UK), Southern Cross Mining Limited (Queensland), Golden Shamrock Limited and Titan International (Australia) [1,3,4].

The above results are the outcome of the liberalization policies on mining, which for the first time since independence from British rule in 1957, allow both nationals and foreigners to take up mineral concessions for exploration and development. The new legislation on mining (Provisional National Defence Council Law 153 alias Minerals and Mining Law, 1986) [1] establishes the basic legal elements of Ghana's mining policy that puts into place regulations concerning the granting of prospecting and mining licences and the guaranteeing of incentives aimed at encouraging the growth of the mineral industry. Some of the incentives include tax holidays, especially during exploration and development of new mines, security of land tenure and equitable disposition of mineral profits. In addition, a Mineral Commission as well as a Precious Minerals and Metals Marketing Board have been established to regulate and monitor the effective exploitation of Ghana's mineral resources.

Alluvial gold mining, which in the past has been the preserve of illicit local gold winners (popularly known in local parlance as "galamsey-men"), has had the greatest boost of the boom and over half of the mineral concessions that have been taken are for this type of deposit.

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However, contrary to the general belief that the development of alluvial deposits is easier, faster and cheaper than that of primary deposits, the results of the Ghanaian experience, to date, do not appear to support this trend.

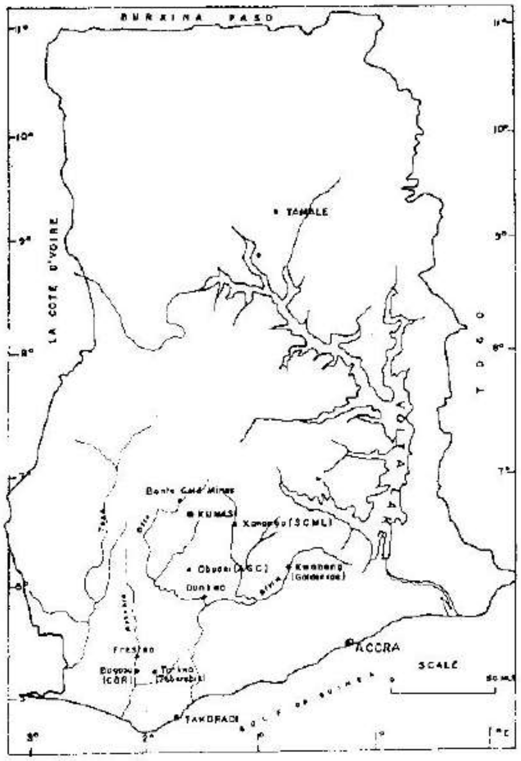

Fig.1 The Location of the New Gold Mines in Ghana

Between 1986 and 1991, four primary lode gold deposits, namely; the Southern Cross Mining Limited at Obenemase near Konongo (Fig. 1); Teberebie Goldfields near Tarkwa; Billiton Bogosu Gold at Chujah near Bogosu and Ghana Australian Gold also near Tarkwa have been brought into production as against the two new mines on alluvial-type gold deposits at Goldenrae Mining Company, Kwabeng and Bonte Gold Mine at Tetrem (48 km Nw of Kumasi).

The reasons often cited for this apparent lack of success in alluvial gold exploration programmes are:

1. Lack of technical know-how,
2. Poor planning and execution of programmes, and
3. Inadequate provision of capital.

This paper, the first in a series, deals with the alleged dearth of technical knowledge in alluvial gold exploration in the country. In 1989, for example, over 30,000 individual local gold miners ("galamsy-men") were estimated to be working alluvial deposits in the country[3]. With the present legalization of such mining activities, it is necessary that these galamsey-men be given technical know-how to make their operations beneficial.

Focus is therefore on the methodology of Kwabeng and Bonte as a model to the exploration and development of alluvial gold deposits in Ghana.

Phases of Exploration

Unlike primary or lode gold deposits, placer gold is mainly sought by geological methods since they are generally not susceptible to detection by geochemical and geophysical methods. The stages of exploration, after desk study, are usually scout prospecting, initial systematic exploration, detailed (close) exploration and deposit evaluation [5]. The present study is, however, confined to the prospecting and exploration phases only: Desk study and ore-reserve computations, the preserve of the expert, being excluded.

The objective of scout prospecting is to quickly assess the extent of gold mineralization of an area to justify the need for further investigation. This is done with the help of aerial photographs and a general knowledge of the local geology and geography. Sites of possible gold concentration (such as the confluences of streams, meanders in river courses and areas around natural riffles in the course of the streams) are investigated by stream sediment sampling.

For comparative results, it is advisable to wash a fixed amount of gravel (say 2 to 4 "headpans" approximately 0.04 to 0.08 cubic metres) at every location during stream sediment sampling with every effort being made that the samples are taken from as close to bedrock as possible. The sampling may also be complemented with a few exploratory pits on river banks provided the finance and time of the operation permit it.

Exploration may be embarked upon only when the scout prospecting has indicated interesting values. "Preliminary" or "Initial" exploration, which involves the careful laying out of a systematic preliminary skeleton framework at fairly large sampling (or pitting) intervals over the whole area, may be done on either the "line" or "grid" system [6]. The line system is faster and cheaper but the grid is more comprehensive. At the early stages of this phase of exploration, Banka drilling, being a faster technique, may be used as an advance prospecting tool (to check for the presence of alluvial gravel) provided the operational expertise is available.

"Close" or "Detailed" exploration, the final stage of the investigations, should only be concentrated on areas where the previous examinations have indicated good values by closing the gap in the initial systematic exploration to actually map out the shape and size of the deposit and calculate its grade and volume. Bulk sampling provides reliable grade estimates and sufficient information on the nature of the deposit to enable selection of suitable mining and beneficiation methods and equipment.

Goldenrae and Bonte Mines

The Goldenrae and Bonte Mines are the two alluvial gold properties that have successfully carried out exploration and evaluation and have gone into production since the current gold boom began in 1986. Not coincidentally, both mines employ similar techniques for their exploration. Both Banka drilling and pitting are used; Banka drilling being used as a scout prospecting tool in advance of the systematic "line-grid" exploration whilst the main exploration work is done by pitting.

During the initial stages of systematic exploration, large pitting intervals of 800m x 100m are used. A baseline, is cut through the property after which pegs are placed at 800m intervals. Cross-lines are laid off at the pegged positions perpendicular to the base lines and pit positions are marked out at 100m intervals on the crosslines as shown in Fig.2.

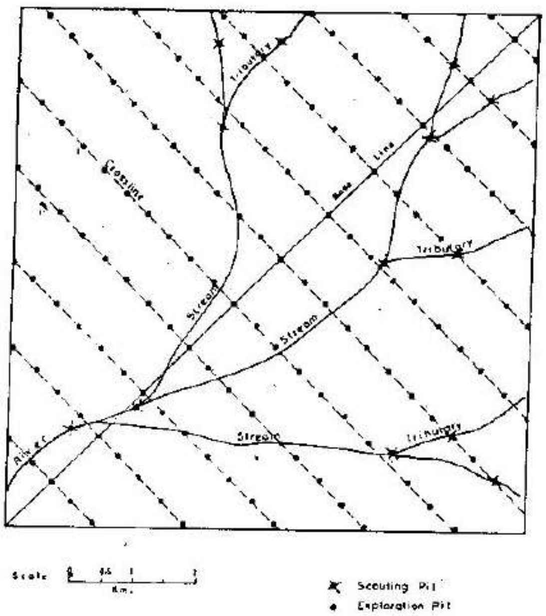

Fig.2. The Layout for Initial Systematic Exploration.
Crossline interval - 1km; Pit spacing = 0.50km

Square pits of 1m x 1m are dug through the overburden and gravel layers into the bedrock using pick-axes, chisels, and shovels. Buckets are used to hoist material from the pits either manually or by means of a rope around a pulley. During pitting, unlike in scout prospecting, when every soil layer is tested for gold, the overburden material is discarded. Utmost care is, however, taken to ensure uniform pit dimensions so that the in-situ volume of the excavated gravel may be accurately calculated. The pits are carefully logged and the contacts of the different layers are identified and recorded for interpretation of geological sections and structures.

During the detail exploration stage, smaller pit spacing, usually half that of the initial systematic stage, is used. Such closely spaced pits are dug around areas that showed good values in the preceding exploration phase.

The common problem of in-rush of ground-water with the attendant collapse of pit walls, that often disrupts pitting operations, is resolved by stabilising the pits with timber planks and boards. The timbering operation, shown in Fig.3A and discussed below, is after Griffis et al., 1990[7].

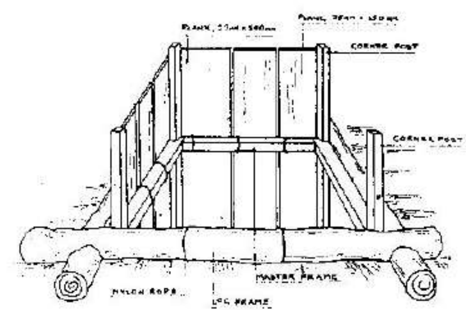

Fig 3a. Timbering Operation

A wooden post of dimension 0.076m x 0.076m x 4.0m is first placed vertically at each corner of the pit. Four large logs are then placed at the surface around the edge of the pit to anchor the frames each of which consists of four 0.076m x 0.076m x 0.96m timbers which are specially notched at each end to fit snugly but levelly to form a square (Fig.3B). The first frame is pushed into place against the corner posts and tied to the logs at the surface. Subsequent frames are then fixed and tied to the preceding ones at 0.5m intervals down the depth of the pit to keep the pit-timber aligned straight and also prevent "bowing" of the planks at the bottom.

At 0.5m above the gravel layer, eight planks each measuring 0.025m (thickness) x 0.03m (width) x 4.0m (length) and another four, measuring 0.025m x 0.015m x 4.0m each, are slid down the sides of the pit between the frames and the pit walls. As pitting advances, the planks are periodically hammered down to the bottom to prevent gravel seepage from the walls into the pit. In areas of torrential groundwater, grass and leaves are squeezed between the planks and the pit walls as added precaution against sand and gravel seepage. The usage of timber support in the pits is the normal practice at the mines at Bonte and Kwabeng where, so far no case of timber failure or collapse of a timbered pit has been reported.

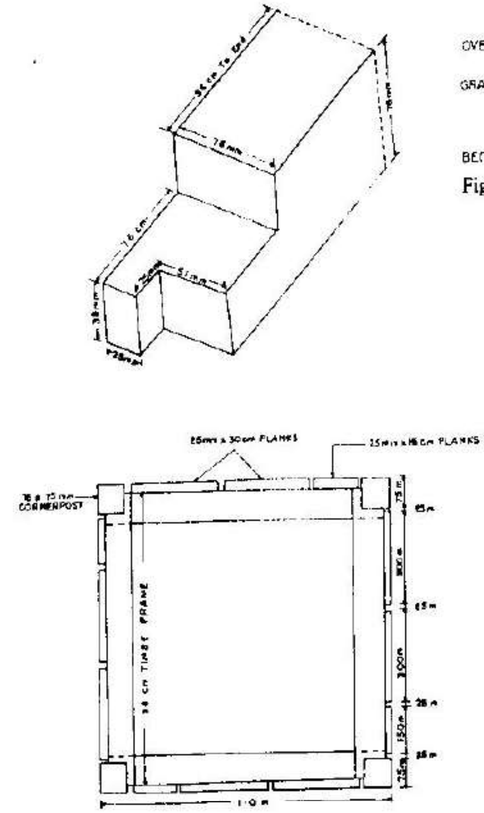

Fig.3B. Notch Cut for Timber Frame
(After Griffis et al.,1990)

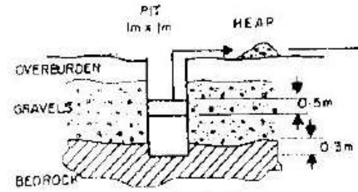

Fig.4A. A Typical Pit Section

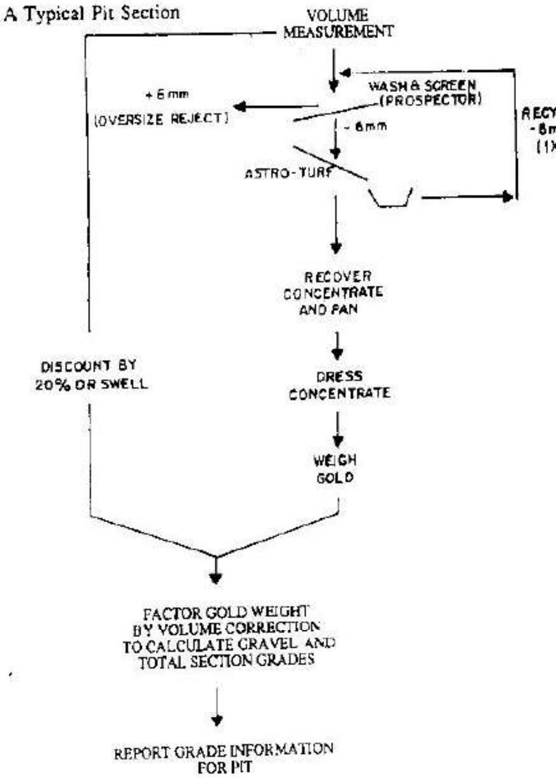

Fig. 4B. Schematic Grade Calculation.
(After Griffis et al.,1990)

At two mines, samples are collected at every 0.5m depth within the gravel layer, heaped separately on tarpaulins around the perimeter of the pit and treated independently from other samples of the same pit (Fig. 4A). Also, in fractured areas or in decomposed bedrock, pitting is proceeded down to 0.3m below the gravel layer into the bedrock and samples from these horizons are always collected and treated for any gold that might have migrated below the gravel horizons (Fig.4A).

Sluicing is the most common method of gravel treatment in Ghana and the traditional sluice box is constructed from boards of "wawa" (a light tropical wood easily obtainable locally). The most common sluice box measures 0.30m in width, 3 to 4m in length and is about 0.04m thick (Fig.5). The sides of the board are bridged with wooden battings to prevent the wash spilling over. The inside of the board is lined with either corduroy material, blankets or jute sacks. At the head of the sluice box is a washing hopper ("bashing-head") which is a rectangular steel box measuring 0.23m x 0.46m and open at one end. The bashing-head is often perforated at the bottom to 6mm mesh sizes to allow the finer material to penetrate onto the washing blanket, leaving the coarser rock fragments on the bashing-head to be discarded through the open end of the head. The sluice box is mounted on wooden trestles as supports (Fig.5) and the gradient is varied depending on the nature of gravel to be washed, the amount of water available and the speed with which the operator wants to accomplish his work [6].

At the mines of Goldenrae and Bonte, however, the samples are washed in a diesel-operated sluice machine called "the prospector" and the concentrates are panned to liberate the gold. To achieve a good wash, the flow of water into the hopper of the prospector is regulated at 45 litres/minute for a solid content of 20-25% in the pulp

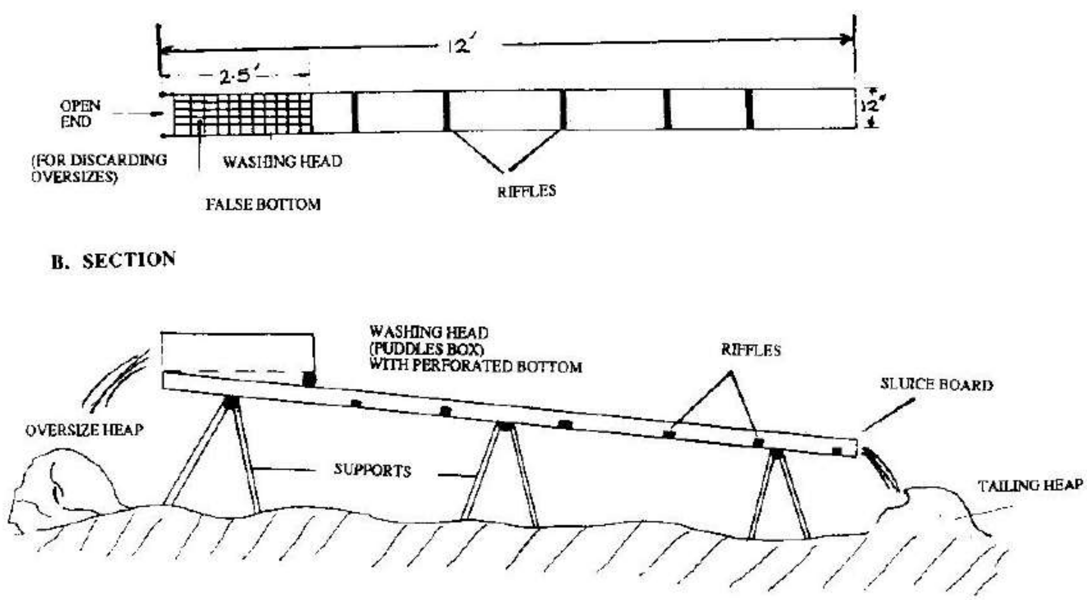

Fig. 5 The Traditional 'Wawa-Board' Sluice Equipment

feed. The material is hand puddled against the flow of water and the pebbles discarded after having been thoroughly washed and cleaned. The tailings are recycled twice to ensure that all the gold is recovered before being discarded.

The astroturf (a special type of corduroy) which is used to line the sluices, is removed after washing each heap of material ($0.5m^3$ by volume) and then washed into a bigger container before the final panning to recover the gold. Sticky clayey gravels and bedrock materials are often soaked to soften them before sluicing.

Volume and Grade Computations

Prior to washing , the volume of the excavated material is determined by measuring it with a specially constructed $0.1m^3$ wooden box. The volume of the loose materials so determined is compared with the in-situ volume and the "swell" for each sample interval is calculated. A swell factor of 20% is considered the average and this is used to discount measured loose volumes back to bank volume. A schematic grade calculation proposed by Griffis et al., 1990 [7] and practiced at Goldenrae mine is shown in Fig.4B. It involves:

(i) the determination of the grade of a pit, and
(ii) the calculation of the grade of a mineable block.

The grade of a pit also involves two components, namely:

(a) the gravel section grade, and
(b) the total section grade.

In gravel section grade calculations, only the thickness or, more precisely, the volume of the gravel is considered whereas in the total section grade, the gold value of the gravel horizon is distributed over the whole thickness of the pit. Normally, however, the total section grade is more useful in evaluating the deposit because it provides the total gold available to pay for the mining and treatment of both the overburden and the auriferous gravels and thus enables the minimum grade at which the deposit could be profitably worked (cut-off grade) to be determined.

Ore reserve calculations for placer gold employs classical or geometric methods that involves averaging the gold values of the pits on a block of ore and weighting each according to its zone or area of influence to determine its contribution of gold to the orebody. The sample value of a pit is assumed to extend half-way to the next pit. A block of ground covers a length of 400m and is defined by a grid line dividing it into two halves.

In a pre-mining phase of deposit development, the use of geostatistical methods of ore reserves calculations may not be advantageous. This is because the large number of samples from which relevant variograms and Kriging estimators may be generated, are normally not available at this stage hence, the geometric methods are preferred even though the results are viewed as only estimates.

Discussions

Apart from finance, some of the short-comings associated with current alluvial gold exploration programmes in Ghana may be due to the following:

A. *Handicap of exploration personnel*

- Inability to setting minimum grades for the various stages of exploration to justify further expenditure on follow-up programmes.

- Indifference in selecting the most appropriate method of exploring the deposit; for instance, would banka, drilling be more suitable than pitting in a particular circumstance or vice versa?

- The unawareness of the importance of pitting down into bedrock where the heavy detritals are most likely to accumulate and the failure to record, during exploration, such vital information as the nature of the gravel horizons, thickness ratios of overburden and gravel layers and the sizes of gold grains and rock fragments which may later be of assistance to mining and processing personnel during evaluation and equipment selection.

B. *Pit stabilization*

Most often exploration pits have had to be abandoned because of water in-rush and consequent pit collapse. The stabilization of pits and regular pumping out of water as done at the mines of Bonte and Kwabeng would prevent such occurrence.

Also, since volume calculations based on pit dimensions assume uniform cross-sections, inaccurate volume determinations may be frequent as many exploration pits generally narrow down in hard ground and widen (with sand seepage) in swampy areas.

C. *Sample treatment*

"Conning and quartering" of dug out gravel material to reduce the volume for panning, as a means of saving time and water generally leads to inaccurate results. Observation shows that it is rather difficult to cone and quarter the large volume of gravel often encountered in the field to obtain a representative sample. In most cases, where the procedure is used, the sample actually treated represents only a limited portion of the gravel layer.

The use of the traditional sluice box to which no riffles are fitted leads to quite an estimated high loss of gold. Also, 'galamsey-men' generally wash a predetermined volume of grave (50 "buckets" approximately 0.5 m^3) before cleaning the blanket linings. This volume does not take into account the nature of the gravel and sluicing is often carried on when the linings of the blankets are completely filled with sand to a point where they are no longer effective in trapping gold fines.

Alluvial gold estimations based on fire assay and the Atomic Absorption Spectrometry (AAS) analyses tend to give comparatively higher assay value than results obtained from the direct mercury amalgamation. However, since during the actual exploitation of the alluvials, acid digestion or roasting process are generally not employed, the values shown by these analyses are not realised.

D. *Bulk Sampling versus Trial Mining*

Either bulk sampling or trial mining must precede feasibility study. Ledgerwood and Hesford, 1991, [8] prefer trial mining to bulk sampling because they assert that it provides better confidence, simultaneous deposit evaluation and processing evaluation leading to a more accurate feasibility study. Trial mining may also generate revenue by sale of product which they claim, may pay off the capital on equipment and partially finance the next stage of deposit evaluation [8]. The Ghana Minerals Commission, on the other hand, prefers bulk sampling as a means of distinguishing between mineral evaluation and exploitation of mineral deposits.

E. *Environmental pollution*

The 'gold-boom' in Ghana has also brought with it the usual environmental problems about which current legislation appears to be silent. For example:

- The digging of alluvial gravels has resulted in the loss of large tracks of fertile agricultural land and unsightly ditches and large man-made lakes have begun to dot the country side.

- Top-soil and vegetation are being rapidly buried underneath heaps of barren pebbles and rock fragment - the waste products of mining.

- Rivers and streams, the source of drinking water for the rural folk, being polluted from the sluicing and dredging of alluvial gravels and large volumes of mercury and nitric acid carried by people who are not properly trained to handle these toxic chemicals.

Waste dumps of heap-leached ore and drainage systems in mining areas need to be monitored to prevent the run-off from these heaps entering drinking waters.

F. Terminology

Aside from the above, the gold business in Ghana is beset with curious terminology that baffles both the academic and the uninitiated; the Ghanaian goldsmith talks about a "bender" or "burner", a pound, blade or match-stick as units of gold measure.

1 "burner" Au = 2 troy ounces gold.

1 pound (£1) = 1/8 "burner" or 0.25 troy onces (8 gm) Au.

10 "shillings" Au = 0.125 troy ounces or 4 gm gold

5 "shillings" Au = 2 gm gold

2 "shillings and 6 pence" Au = 1 gm gold

1 "blade" Au = 0.5 gm gold; and,

1 "match-stick" Au (the weight of the unlighted traditional match stick) equals 0.1 gm of gold

whilst the word "galamsey" is a catchy adulteration of "Let's gather (the gold) and sell."

CONCLUSION

We conclude that since mining is capital intensive and a wasting asset:

(a) Maximum returns on investment must be derived from the exploitation of mineral deposits. A programmed and systematic exploration of gold placers is recommended, as it is the results of such programmes that define the method and equipment most suited for beneficial exploitation of the deposits; and,

(b) Mining legislation should be enacted to prevent any degradation of the environment that the current increased mining activities may bring in their stride so that the gains of the gold boom may be seen as improving the quality of life.

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