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THE SOURCE OF PLACER GOLD IN THE WALAWE GANGA BASIN, SRI LANKA

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ABSTRACT

Significant quantities of alluvial gold occur in the zone lying between the gem-bearing gravel layer and the decomposed bed rock of Walawe Ganga, a river draining a Precambrian Highland Complex rock terrain of Sri Lanka. In such zones, the gold content varies from place to place and concentrations up to 9g per tonne of sediment were observed. The gold grains show different morphological features and occur as dust, flakes and nuggets. Some grains contain 100% Au whereas others have lesser amounts with the balance being constituted of Ag, Cu and Mn.

The highest alluvial placer gold concentrations are found in zones of intense shearing and fracturing in the country rock which is commonly intruded by quartz veins and pegmatites. Both shears and fractures show sulphide mineralization. Hydrothermal solutions with high CO_2 and S components had been active during or after the deformational phase that formed the shears and the fractures. Such solutions appear to have been responsible for the gold mineralization in the Walawe Ganga basin..

1. INTRODUCTION

Various historical records[1,2] give evidence of gold mining in different parts of ancient Sri Lanka. One such location is in the village of *Acaravittigama*, presently known as Kebithigollawa, near the ancient city of Anuradhapura. The native gold had various shapes and occurred as nuggets or grains having a dendritic form with sizes up to several centimetres in length.

According to the Central Province Administrative reports[3] several attempts to mine gold were made in the Nuwara Eliya and Ramboda areas at the end of the 19th century (Fig. 1). Gold concentrations as high as 2 ounces per ton had been mined from a quartz vein in the Ramboda area. Ceylon Administrative Reports[4] show that gold is present in small amounts in stream sediments in the central, south-western and southern parts of the country. Recent geochemical investigations have shown occurrences of relatively high gold concentrations in the areas of central highlands[5].

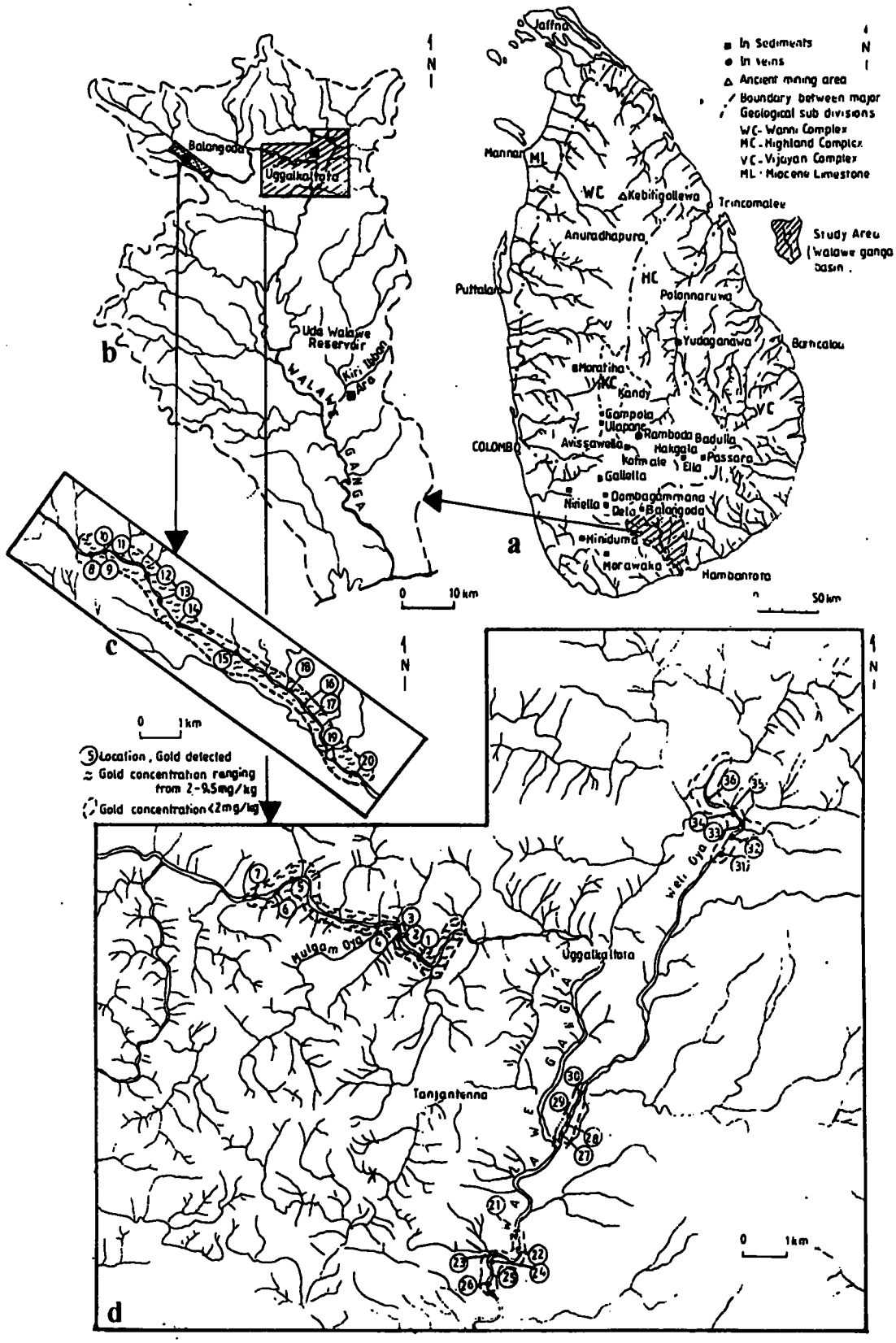


Fig. 1. **a.** Map of Sri Lanka showing (i) the broad geological divisions (WC, HC and VC) (ii) the locations of gold occurrences and (iii) study areas. **b.** Enlarged study areas of Balangoda and Uggalkaltota in the Walawe Ganga basin. **c.** Sample locations of Balangoda study area. **d.** Sample locations of Uggalkaltota study area.

The results of the recent geochemical survey confirm the occurrence of gold in the vicinity of villages having names such as Ranketi Ela (meaning - Gold nugget stream) that imply gold mining during ancient times[6]. The association of gold with heavy minerals in gem-bearing sediments of the Balangoda-Weligepola area (Fig. 1) was reported earlier[7,8]

Currently, small amounts of placer gold are recovered by miners using traditional mining techniques specially developed for gem mining in rivers. Mammoties with long wooden handles are employed to recover both gemstones and gold by a process of dredging. This technique lets running water sort out and remove the lighter particles from the dredged river bed leaving behind a pile of heavy sediments and gravels. The gemstones and gold grains are hand picked or collected by panning the heavy sediments. From flood plain sediments of the river- Kiri Ibban Ara, gold is recovered directly by panning (Fig. 1).

This paper reports the results of geological, sedimentological and geochemical studies carried out in the Walawe Ganga basin of southern Sri Lanka (Fig. 1)

2. GEOLOGIC SETTING OF THE STUDY AREA

High-grade metamorphic rocks of Precambrian age known as Wanni Complex (WC), Highland Complex (HC) and Vijayan Complex (VC)[9] cover more than 90% of Sri Lankan landmass (Fig. 1). The upper part of Walawe basin belongs to the HC and is underlain mainly by charnockites with occasional high garnetiferous varieties. The other major rock types include biotite (-garnet) gneiss, quartzite, crystalline limestone, undifferentiated metasediments (local name for assemblages of garnetiferous graphite gneiss, graphite bearing gneiss, graphite sillimanite-garnet gneiss etc.). In the charnockitic rocks, pyrite occurs as an accessory mineral. Crystalline limestones are found interbedded with the other rocks or as plastically mobilized structures cross cutting the adjacent rocks.

The width of pegmatitic intrusions (with well developed graphic texture and quartz veins) varies from a few millimetres to several meters. Large intrusions of syenitic composition with big zircon crystals occur in the Walawe basin near Balangoda (Fig. 1). Significant amounts of pyrite, muscovite and carbonate minerals are found in the shears and fractures as secondary minerals. Walls alteration of the mineralized fractures is characterized by occurrences of carbonate minerals, hornblende and biotite. In addition, quartz veins and pegmatites are associated with large garnets, sulphide minerals and radially arranged graphite.

A high intensity of shears and fractures is noted in the study area and the local drainage is controlled by these structures. Some parts of the Walawe Gangar flow for more than 20 km along a lineament.

3. COMPOSITION OF WALAWE GANGA SEDIMENTS

The upper part of the Walawe Ganga is rich in gemstones and has a long history of gem mining. The gem minerals that occur in the gem-bearing gravel layers of this area are:

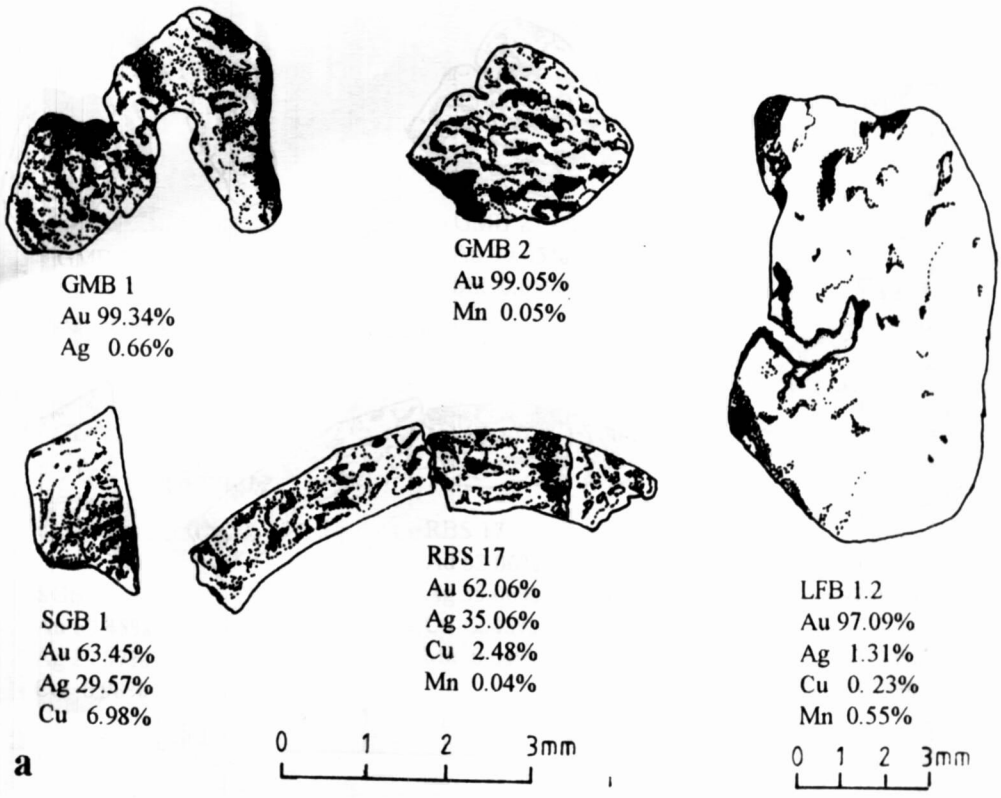
Corundum: blue, white, pink and yellow sapphires, rubies, star varieties and geuda
Beryl: white beryl and aquamarine
Chrysoberyl: alexandrite, cat's eyes and chrysoberyl with honey colour and other shades
Garnet: almandine, pyrope and grossularite
Zircon: varieties of green, purplish and other colours
Spinel: varieties of different shades of colours (pink and purple are common)
Tourmaline: varieties of green, yellow and various other shades (black common)
Topaz: mainly colourless large grains
Quartz: white quartz, amethyst, smoky quartz, and cat's eye

The heavy minerals are concentrated in the gem-bearing sediment layer. In the panned concentrates of the sediments from the gem-bearing layer, ilmenite and garnet are found as the dominant minerals . Rutile, monazite, tourmaline, corundum, zircon, diopside, apatite, spinel, pyrite and topaz occur as accessories. Due to their high specific gravity, gold grains in the form of dust, nuggets and flakes have concentrated in the zone between the gem-bearing layer and the underlying decomposed rock.

Table 1- Gold Content in the Bottom* Sediments of Walawe River
(mg/kg of sediments; Sample locations are as given in Fig. 1)

Location	Gold Content	Location	Gold Content	Location	Gold Content
2	9.33	8	4.09	14	3.15
3	3.43	9	5.18	15	4.50
4	3.75	10	4.35	16	3.52
5	3.80	11	3.81	17	3.43
6	5.70	12	3.29	18	4.02
7	9.28	13	3.27	19	2.76

*The bottom sediments are collected from the zone lying between the decomposed bedrock layer and gem-bearing gravel layer.



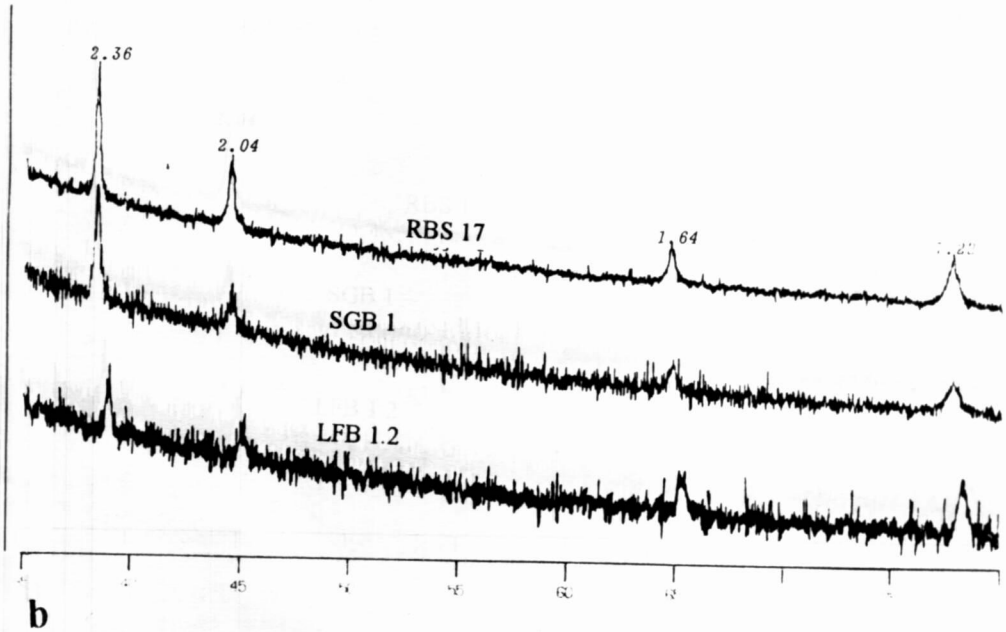


Fig 2. **a.** Texture and chemical composition of gold grains collected from the sediments of Walawe Ganga basin **b.** X-Ray Diffractogram of some selected gold grains confirming their crystalline nature

Gold was found in the sediments in varying concentrations from <0.1g/t to more than 9g/t along the Walawe Ganga. Table 1 records the values greater than 2g/t.

4. TEXTURE OF GOLD GRAINS

In the studied samples of Walawe Ganga and its tributaries, the maximum length of gold grains varies from <0.5mm to about 7mm. The large grains (>1g) are found in the main stream of the Walawe Ganga.

Grain morphology was studied under reflected light using the petrological microscope. More detailed observations were made using the Electron Probe Micro Analysis (EPMA) using both secondary images (SE) and back-scattered images (BSE). The outer contours, corrugation and undulations on the grain surface were used to determine the history of the grains since their release from the host rock. Some grains are angular in shape but show corrugations perhaps due to attrition. Others grains are nuggets with depressions of various shapes and partially rounded outlines. The grains with rounded outlines and corrugations and depressions may have a longer history in the sediment than those with sharp edges. The gold grains with angular outlines (Fig. 2a) indicate little or no transportation since their release from the source rock. The presence of relatively large gold grains with high angularity indicates that they have reached the river at points not far from the sites of primary mineralization.

5. COMPOSITION OF GOLD GRAINS

The gold grains were cleaned by boiling in dilute HCl and washing with distilled water in an ultrasonic vibrator for 15min. *X-Ray Diffractometry (XRD), Electron Probe Micro Analysis (EPMA) and Energy Dispersive Analysis of X-Rays (EDAX) confirmed the mineral and chemical composition of the grains. All the measured grains gave perfect X-Ray diffractograms (Fig. 2b) indicating that the grains are not amorphous. The analysis also showed that the silver content of individual grains varies from about <1% to 35%. The grains with angular outlines (Fig. 2a) gave high values for silver which is characteristic of gold-silver alloys (electrum)[10]. Table 2 shows some additional information on the chemistry of gold grains.

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*XRD - Shimadzu XD-7A, 40KV, 30A, Cu-tube, rate 1(2)/min.

EPMA - Shimadzu 8705/LiF & RAP analyzing crystals, operated at 20KV, 25-35A & 100μm probe size

EDAX - Seiko SEA2010L / Rh-tube

Table 2 Composition of gold grains

Sample No.	Au%	Ag%	Cu%	Mn%	Analytical Method
LFB1.2	97.90	1.31	0.23	0.55	EPMA/EDAX
RSB12	99.24	0.10		0.65	EPMA/EDAX
RSB17	62.06	35.06	2.48	0.40	EPMA/EDAX
SGB01	63.45	29.57	6.98		EPMA/EDAX
GMB1	99.34	0.66			EPMA/EDAX
GMB2	99.50			0.50	EPMA/EDAX
GMB3	100.0				EPMA/EDAX
WO/5	97.65	0.95			EPMA*
WO/7	96.30	1.70			EPMA*
WG/11	98.20	0.70			EPMA*
WG/18	98.65	0.85			EPMA*

6. DISCUSSION AND CONCLUSION

The study shows that gold occurs in varying amounts in the sediments of the Walawe Ganga. Along the course of the river, gold occurrence and grain angularity showed irregular and anomalous distributions. These findings indicate the contribution of gold grains to the river sediment from various different locations thereby suggesting the presence of several sites of gold mineralization in the Walawe Ganga basin.

The alluvial gold grains with low silver contents imply that (i) natural gold grains in the source rocks had a low silver content or (ii) original high silver content had decreased due to leaching within the sediment over a long period of time. It should be noted that some grains show higher silver contents in their core and lower amounts along their peripheral zones. The different silver contents also could indicate multiple sites of gold mineralization.

Walawe Ganga basin is underlain by a zone of intensive deformation with closely distributed shears and fractures some of which extending to several tens of kilometres. Alteration minerals[11] such as sulphides, carbonates, quartz, biotite, garnet and hornblende on the walls of these fractures and shears give evidence for fracture filling mineralization. In addition pegmatitic intrusions associated with quartz veins and large mica mineralizations and sometimes rich in topaz represent active pegmatitic and hydrothermal phases.

Collected and analysed by Mr. S. Weerawarnakula, University of Moratuwa, Sri Lanka

The more recent geological structures of shearing and fracturing found in the Sri Lankan Precambrian rocks are favourable sites for fracture filling type mineralization. Such mineralizations and associated quartz veins are the possible sources of placer gold in the Walawe river basin. This area is lying in the southernmost part of a zone recognized as a mineralized belt[12]. The research on gold mineralization in Sri Lanka is being continued as there is a potential of locating economic quantities of gold.

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