OXYGEN ISOTOPE PROVENANCE STUDY OF GOLD-BEARING BANKET CONGLOMERATE QUARTZ PEBBLES, TARKWAIAN GROUP, GHANA

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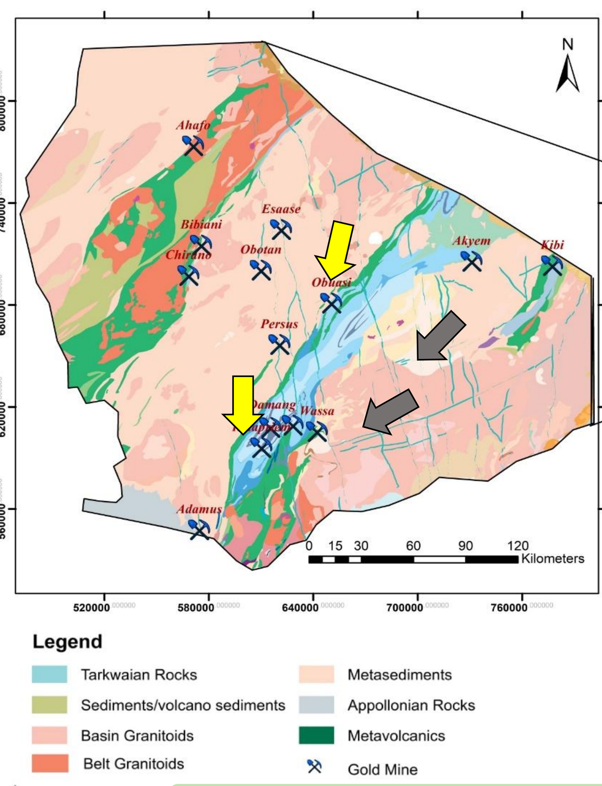
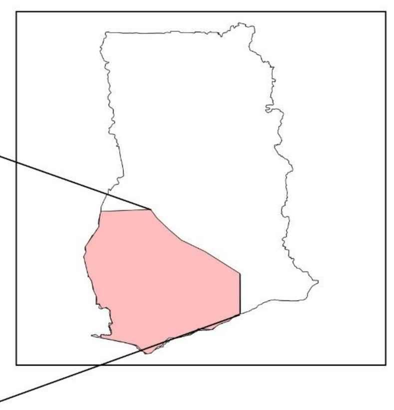
Introduction

Provenance Model Ideas:

- Sourced from the Western Flank of the Ashanti gold belt
- Sourced from the Eastern Flank of the Ashanti gold belt

Fig.1 Geological Map of SW Ghana

Provenance of the gold-bearing Banket quartz-pebble conglomerate

Model 1 (e.g. Klemd et al., 1993; Junner et al. 1942; Kesse 1985; Hirdes et al. 1988).

- Erosional derivative of Western-flanked Birimian lode gold such as Obuasi, Prestea and Bogoso. This was based pebble morphology and huge gold content and exposures of these Western-flanked deposits. Western Flank deposits = Gold deposits located on or away from the western "shear zone" structure along the Ashanti gold belt.

Model 2 (e.g. Sestini 1971, 1973; Oberthur et al., 1998; Perrouty et al., 2012, 2015; Luders et al., 2015; Le Mignot et al. 2017)

- Sourced from east of the Ashanti gold belt (e.g. Golden Star Wassa Deposit)- based on zircon U-Pb age, geophysical and structural analysis, and paleocurrent directions.

Study Area

- Latitude $05^0\ 18'$ N
- Longitude $001^0\ 59'$ W
- 320km West of Accra
- 85km north of Takoradi

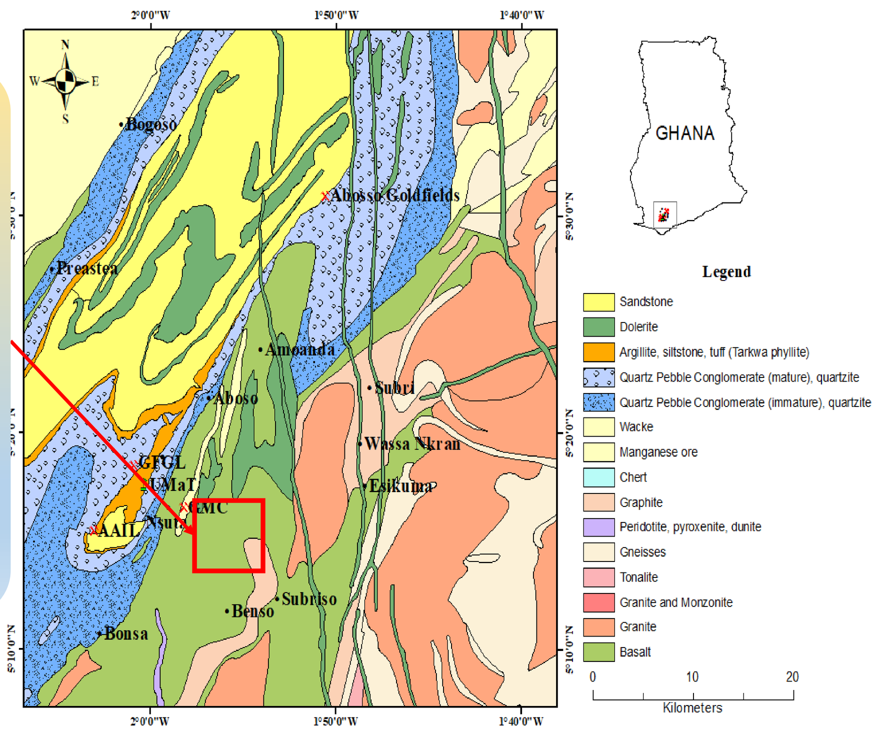


Figure 2 Geological map of South-West Ghana

Results and Discussions

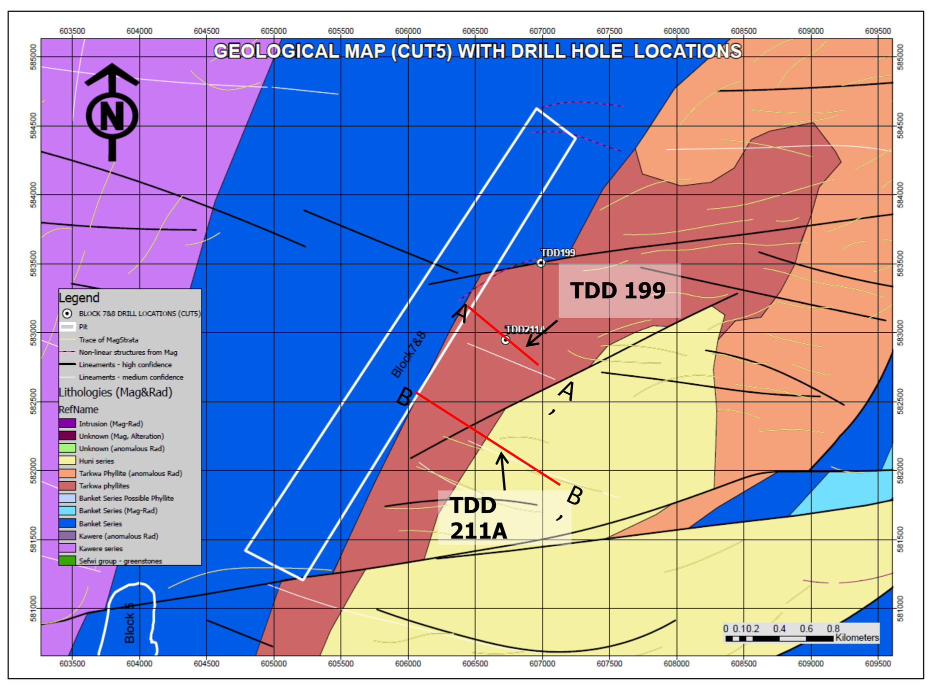


Fig. 3 Geological Map of Iduapriem mine

SECTION A-A' (TDD 199)

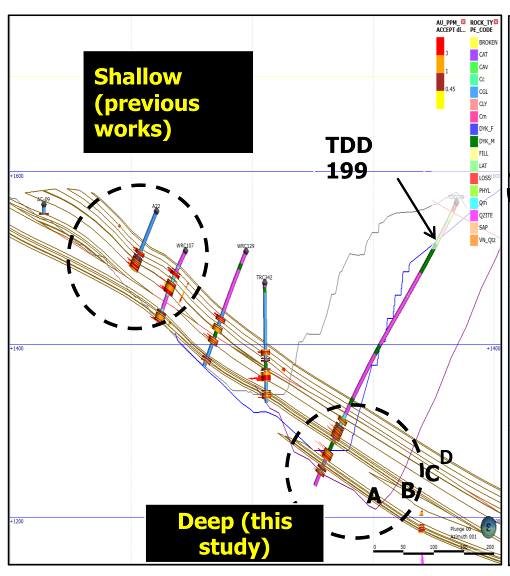


Fig. 4a cross section A-A' showing intercepted reefs for Hole BD 199

SECTION B-B' (TDD 211A)

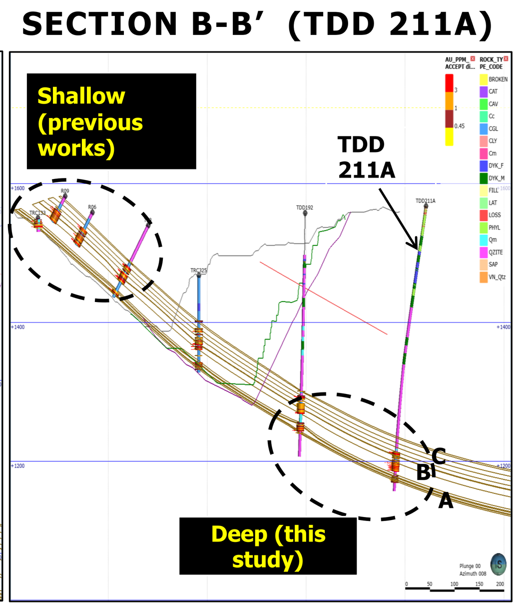


Fig. 4b cross section A-A' showing intercepted reefs for Hole BD 199

Petrology

Fig. 5 Reef C in drilled core of Hole TDD 211A

Gold grade

Pebble morphology and implication for transport

$\delta^{18}O$ values

+11.9‰ and +13.0‰

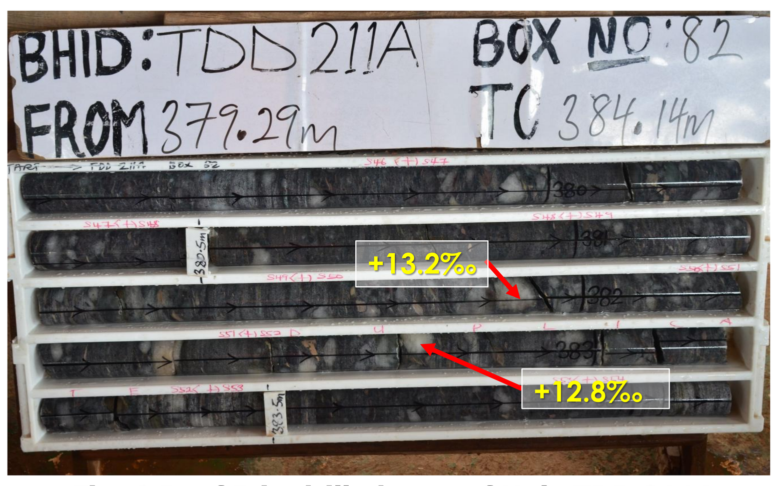


Fig. 6 Reef B in drilled core of Hole TDD 211A

Gold grade

8.8 and 4.1 g/t

Pebble morphology and implication for transport

- Well rounded; Poorly-sorted
- Fluvial transport

$\delta^{18}O$ values

+13.2‰ and +12.8‰

Fig. 7 Reef A in drilled core of Hole TDD 211A

Gold grade

8.8 and 4.1 g/t

Pebble morphology and implications for transport

- Well rounded; Poorly-sorted
- Fluvial transport

$\delta^{18}O$ values

+13.2‰ and +12.8‰

Results and Discussions

Descriptive Statistics

	Range	Min	Max	Mean	Std. Dev	Variance	Skewness	Kurtosis
Au g/t	6.5	2.3	8.8	4.4	2.6391	6.965	1.539	2.571
$\delta^{18}O$	1.6	11.6	13.2	12.5	0.7071	0.5	-0.53	-2.518

Correlation of Oxygen Isotope vs. Au (g/t)

- Close to normal distribution (George & Mallery, 2010)
- Not widely spread out

Correlation Analysis

	Au g/t	$\delta^{18}O$
Au g/t	1.00	
$\delta^{18}O$	0.52	1.00

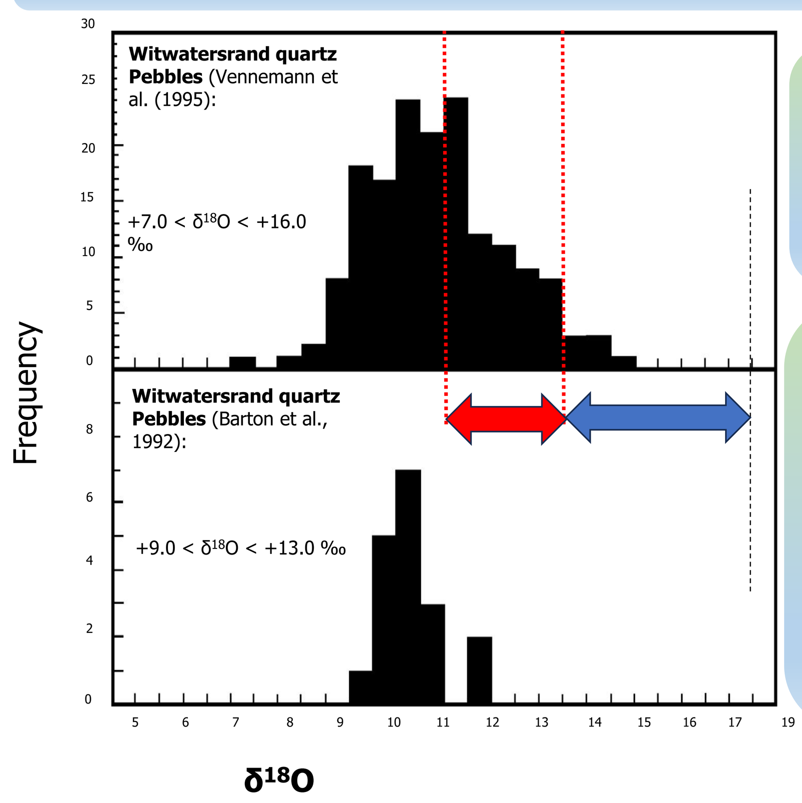
Moderate positive correlation

Regression Analysis

Hypothesis	Regression weights	Beta Coefficient	R^2	F	p-value	Hypotheses supported
H1	Au (g/t) O18	1.94	0.270	1.111	0.369	No

- model explains 27% of the variance in Au (g/t)
- $p > 0.001$, which indicate that $\delta^{18}O$ plays insignificant role in causing unique variance in Au (g/t)

Comparison of Oxygen Isotope Data



Tarkwaian Banket conglomerate quartz pebbles: $+11.0 < \delta^{18}O < +13.5$ ‰ (This study)

Birimian gold-bearing quartz veins (Obuasi, Bogoso & Prestea; *Hammond and Shimazaki, 1994; Oberthur et al., 1996; Mumm et al., 1997*):

$+13.5 < \delta^{18}O < +18.5$ ‰

Tarkwaian Banket quartz pebbles (*this study*)

Birimian gold-bearing quartz veins (Obuasi, Bogoso & Prestea; *previous works***)**

Fig. 10 Chart comparing plot of $\delta^{18}O$ of the quartz pebble of the Banket conglomerate and that of Birimian gold bearing quartz vein

Nature of Parent Source Material

HYDROTHERMAL FLUID	$\delta^{18}O_{water}$	ENVIRONMENT
Seawater	~0±2‰ $\delta^{18}O_{water}$	Volcanogenioc Massive Sulphide
Meterioc water	<0‰ $\delta^{18}O_{water}$	Epithermal Gold Deposit
Magmatic	+6 ‰ to +10‰ $\delta^{18}O_{water}$	Porphyry System (Cu, Au)
✓ Metamorphic	+4 ‰ to +25‰ $\delta^{18}O_{water}$	Mesothermal, Hypothermal

Using Matsuhisa et al (1972) quartz-water oxygen isotope fraction equation

$$\delta^{18}O_{water} = \delta^{18}O_{qz} - [\ 3.34(10^6/T^2) - 3.31\ ]$$

Where,

T= temperature of fluid inclusions in Banket pebbles

(**350 to 450ºC;** Luders et al. 2015)

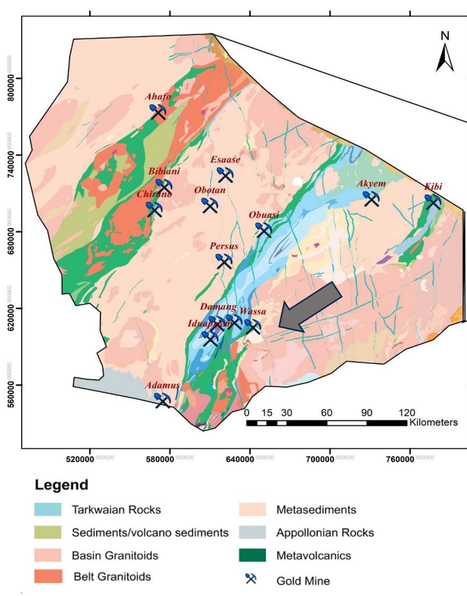
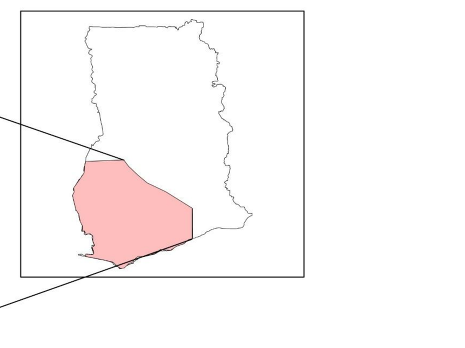
$\delta^{18}O_{qz}$= oxygen isotope value of precipitated quartz (this study);

$+11 < \delta^{18}O < +13.5$ ‰

$\delta^{18}O_{water}$ = oxygen isotope of hydrothermal water responsible for the formation of parent vein quartz at a particular temperature, T.

ANS: $\delta^{18}O_{water}$= +5.9 to 10.1‰ implies mesothermal Au deposits

(NOTE: a magmatic hydrothermal origin would have required T>450 ºC)

- Sourced from the Eastern Flank of the Ashanti gold belt?

Fig. 11 Geological map of South West Ghana showing possible origin for Banket conglomerate gold-bearing placer deposits

Based on the oxygen isotope study;

- Provenance of the Banket was NOT from the western flank of the Ashanti metavolcanic belt.
- Inconclusive for the eastern flank because no oxygen isotope data from the eastern flank for comparison.
- **Tarkwaian placer Au deposit likely sourced from lode gold deposits that have long been eroded.**

Conclusions

- Morphology of the quartz pebbles: well-rounded to subrounded and poorly sorted supports the **fluvial transport of pebbles and Au for shallow and deep sections of the Banket conglomerate**. However;
- New data on $\delta^{18}O$ values of quartz pebbles from the gold-bearing reefs: **$+11 < \delta^{18}O < +13.5$ ‰ (this study) suggest that the pebbles were not sourced from the Western flank** (Western flank auriferous veins: $+13.5 < \delta^{18}O < +18.0$ ‰; Hammond and Shimazaki, 1994; Oberthur et al., 1996; Mumm et al., 1997); but from mesothermal Au deposits on the eastern flank such as the Golden Star Wassa Au deposits, as also proposed by Perrouty et al. (2015) and Le Mignot et al. (2017)
- The possibility of deep erosion of the mesothermal gold deposits to form the Banket conglomerate may be supported by the few (remaining?) gold deposits that are dotted on the Cape Coast Basin and Kibi-Winneba Greenstone belt to the East of the Ashanti Belt in contrast to the prolific, abundant and anomalously gold-rich deposits to the West of the Ashanti gold Belt (the Western Flank), despite over 100 years of mining.

Acknowledgement

This research **was supported by the Ghana Chamber of Mines Tertiary Education Fund (GCM-TEF) through the University of Mines and Technology.** The authors are grateful to the Management of **AngloGold Ashanti Iduapriem Mine** for giving access to the exploration site for data collection. SEG for the opportunity to present this work at the SEG International Conference.