Artisanal and Small-Scale Gold mining in the Wa-East District of Ghana (ASGM): Petrology and Petrogenesis of the study area

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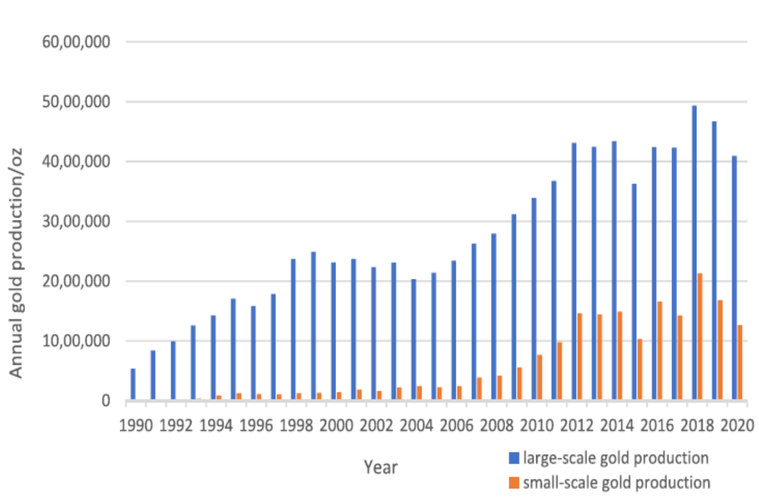
Introduction

Artisanal and small-scale mining (ASM) involves low-technology, labour-intensive mineral processing and extraction. ASGM is an essential way of life for about 45 million people around the world (World Bank, 2020) and makes an important contribution to economic development in many developing countries. In Ghana, Malawi, and Peru, ASGM supports foreign exchange, employment, income, and livelihood diversification for both skilled and unskilled workers (Adranyi et al., 2024). Africa has around 10 million artisanal miners, most unlicensed, extracting gold, diamonds, bauxite, and more (World Bank, 2020). In Ghana, gold is the primary mineral extracted by around 1 million ASGM workers. The artisanal and small scale gold mining (ASGM) sector now accounts for about 35% of the nation's gold production. In Ghana and globally, most ASGM workers operate informally (Bansah et al., 2018).

In this paper, we present detailed geochemical data on the petrology of the Wa-East District area which has enabled the author to assess the petrogenesis of the study area.



Ghana's gold production in the large and small-scale sectors from 1990 to 2020.
urce: Gold production (1990–2015) retrieved from Ministry of Finance - GHEITI Secretariat (2018); gold production (2016–2020) obtained from Minerals ssion (2021).

Figure. 1: Gold production in Ghana from 1990 to 2020

Study Area and Geology

- The Legislative instrument (LI 1746) in July 2004 brought forth the Wa-East district from the original Wa district. Funsi, which is the district capital of the Wa-East district, is located 115km south of the Upper West region.
- Birimian sequence of interbedded foliated metasedimentary metavolcanic units which have been intruded by the medium-grained granitoid and a diorite (Nangodi greenbelt)
- Julie greenstone belt (Basalts, gabbros, volcano sediments)
- Bole Nangodi greenstone belt
- Wa Lawra greenstone belt (shales, volcanosediments, basalts and granitoids)
- North Koudougou – Tumu granitoid domain
- TTG – Tonalite trondhjemite Granodiorite

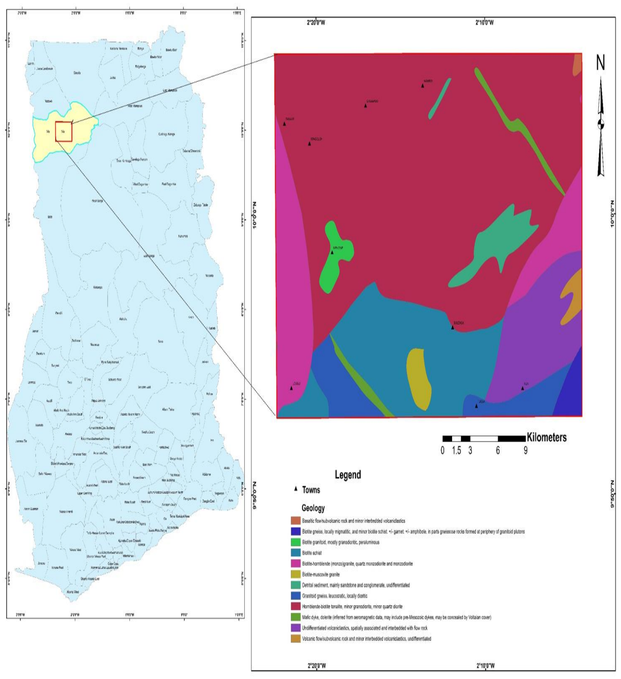
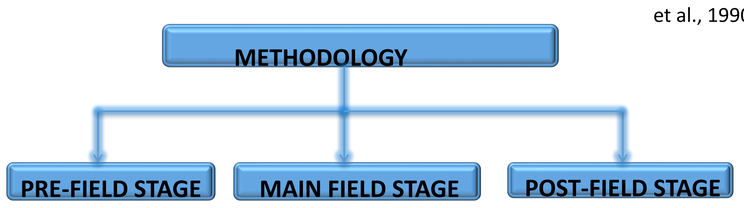


Figure. 2: Map and Geology of the study area (modified after Leube et al., 1990).



- Desk study
- Assembling of field kits and logistics
- Mesoscopic observation of outcrops and taking of fresh and oriented samples
- Geochemical analysis of selected samples (major and trace elements)

Figure 3. Methodology flowchart

Results and discussion

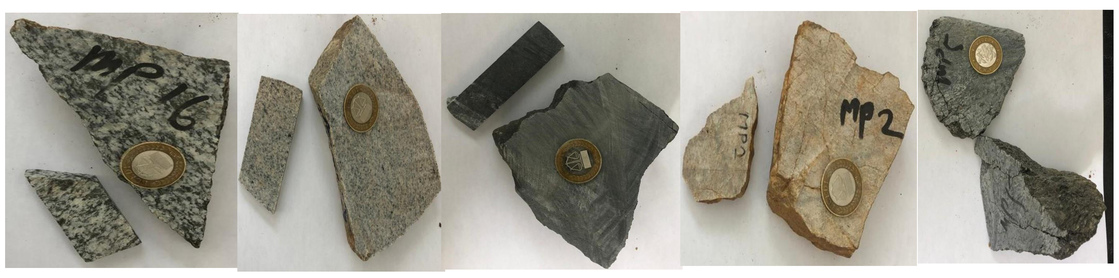
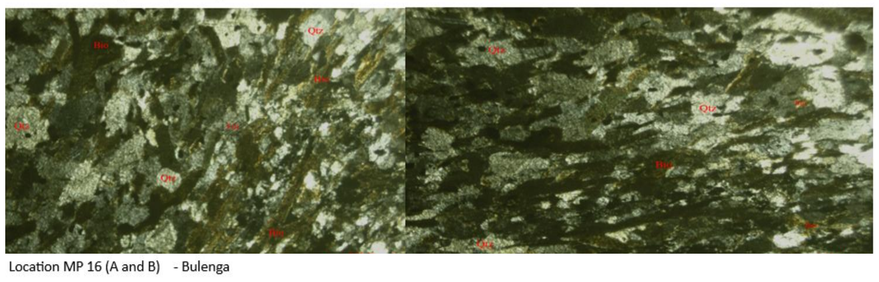


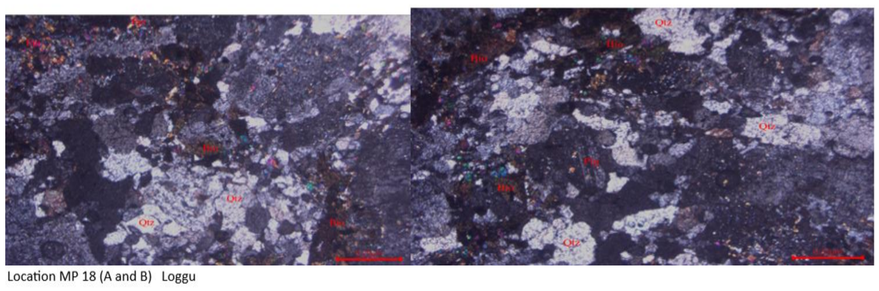
Figure 4: rock samples labelled (MP 15, MP 18 , MP 12 and MP 2) from left to light

- Results from the research illustrates high titanium (Ti) levels in MP 18 which is particularly striking, it holds the highest variability (Ti) (CV-91.8%) reflecting diverse rock types from ultramafic to felsic. MP 18 rocks picked from the community of Loggu. The high-Ti mafic rocks (15,9000ug/g) indicates possibly Ti-rich basalt or ferropicrite associated with Fe-sulphides, however the literature describes these rocks as biotote hornblende, granite and quartz monzodiorite from a plutonic suite.
- MP2 from literature is biotite granitoid however ICP-MS analysis reveals an evolved felsic rock (high SIO2, high Zr, Y and Rare Earth Elements (REE)s low Mg, Ca, Fe) MP 5 and MP 12 are made up of biotite granodiorite and biotite schist, respectively, however, these rocks have magnesium levels greater than 14000ug/g,

Location : MP 12 (A and B) - Goripie



Location MP 16 (A and B) - Bulenga



Location MP 18 (A and B) Loggu

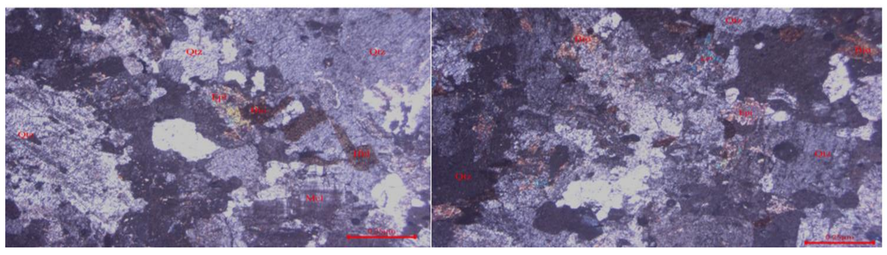


Figure some thin sections of rock samples in figure 4 (MP 16, MP 18 and MP 12)

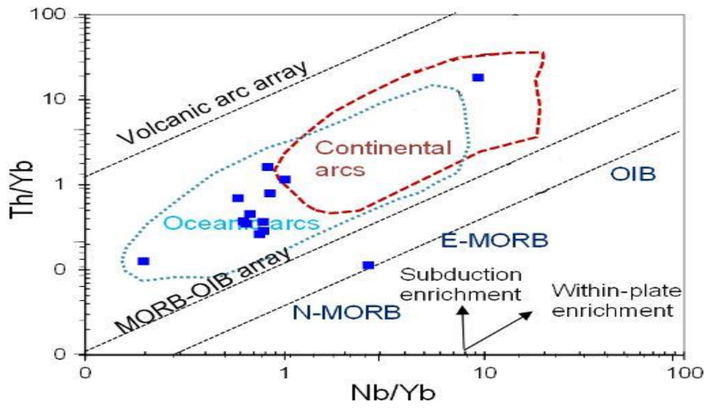


Figure 5: Element ratio diagram

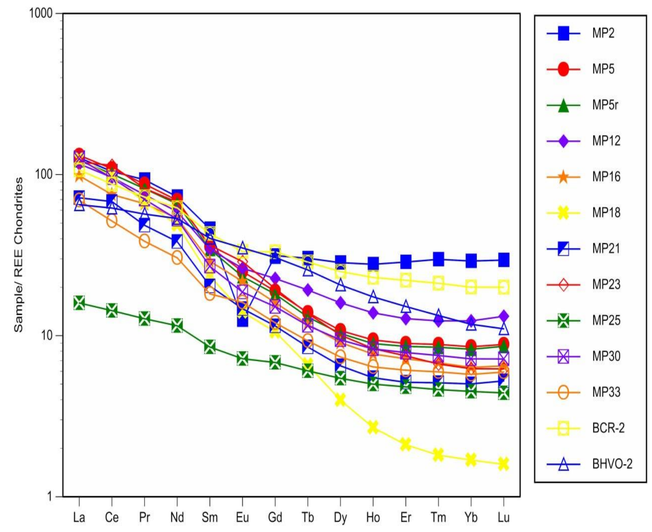


Figure 6: chondrite diagram

MP 2 rocks picked from the community of Manwe in the study area illustrates a strongly fractionated REE pattern (High La/Yb) typical of continental crust from the ICP-MS results.

Some key points

- On groundwater contamination potential of the study area, there is a high potential of hardness ions (Ca2+ , Mg 2+).
- Weathering into groundwater are likley MP 5, 16 and 12 that had elevated levels of magnesium (Mg), Calcium (Ca) and Iron (Fe), In kpanamona, where samples MP 25, was collected the results indicated high chromium levels and low nutirents, this acid rock drainage based on the fact that there are elevated levels of Ni, Co and Cu.

Trace and rare earth element (REE) contents

Element Ratio Diagram (such as Th/Yb vs. Nb/Yb): The samples fall between the Ocean Island Basalt (OIB) and continental arc regions, suggesting multi-stage melting or contamination.

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Rare Earth Elements (REE): La-Lu show overall synchronous changes, but some samples (such as MP18, MP25) show negative Eu anomalies (Eu/Eu < 1), suggesting plagioclase fractionation and crystallization

Summary and Conclusion

Rocks in the study area (Figure 2) dip between 36^0 and 60^0 to the NW. Striations in the faults trend 1300 and plunge 30^0. East-West dips in the Julie district range from 35^0 to 70^0 to the north, with a stretching mineral lineation (Amponsah et al., 2015). The Wa-East gold district occurs within the Julie greenstone belt, an E–W-trending structure bounded to the east by the Bole-Nangodi greenstone belt, to the south by the Bole–Bulenga domain, to the west by the Wa-Lawra greenstone belt, and to the north by the Koudougou-Tumu granitoid domain. The Julie Greenstone belt gold deposit is currently the highest-grade in NW Ghana. The Wa-East gold district also includes gold mining companies and areas of Collette, Kjersti, Kandia, Julie West, Baayiri and Danyawu. The Julie deposit is hosted in strongly sheared granitoids of the Julie belt. The rocks are pink on both fresh and weathered surfaces in the altered zone, and greenish in the least-altered zone (Abitty et al, 2016). They are medium to coarse-grained, weakly magnetic in altered zones and strongly magnetic in the least-altered zones. The mineral deposits, however, are well known to be associated with hydrothermal alterations. They are primarily composed of quartz, plagioclase, hornblende and biotite, with accessory minerals including titanite, zircon and magnetite, which are overprinted by greenschist-facies metamorphic assemblages of epidote, calcite, fine-grained biotite and rutile.

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