Tectonics and Metallogenesis of NE South America

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PETROGRAPHY, GEOCHEMISTRY AND AGE OF THE PALEOPROTEROZOIC ARMINA FORMATION METATURBIDITES OF THE COPPENAME RIVER IN SURINAME

by

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INTRODUCTION

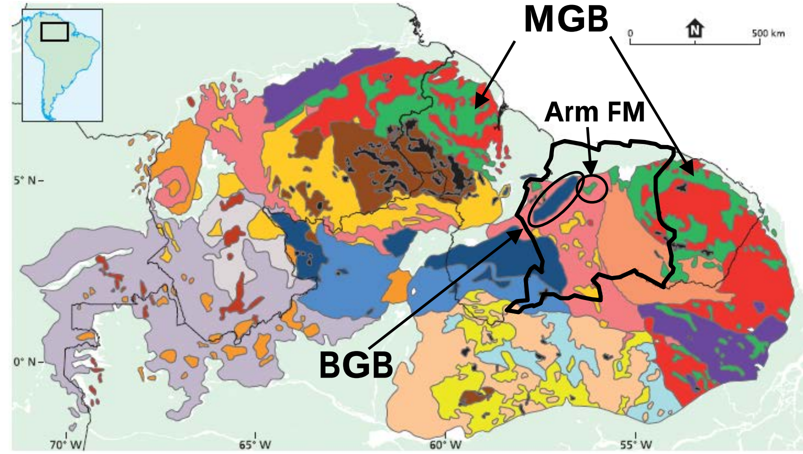
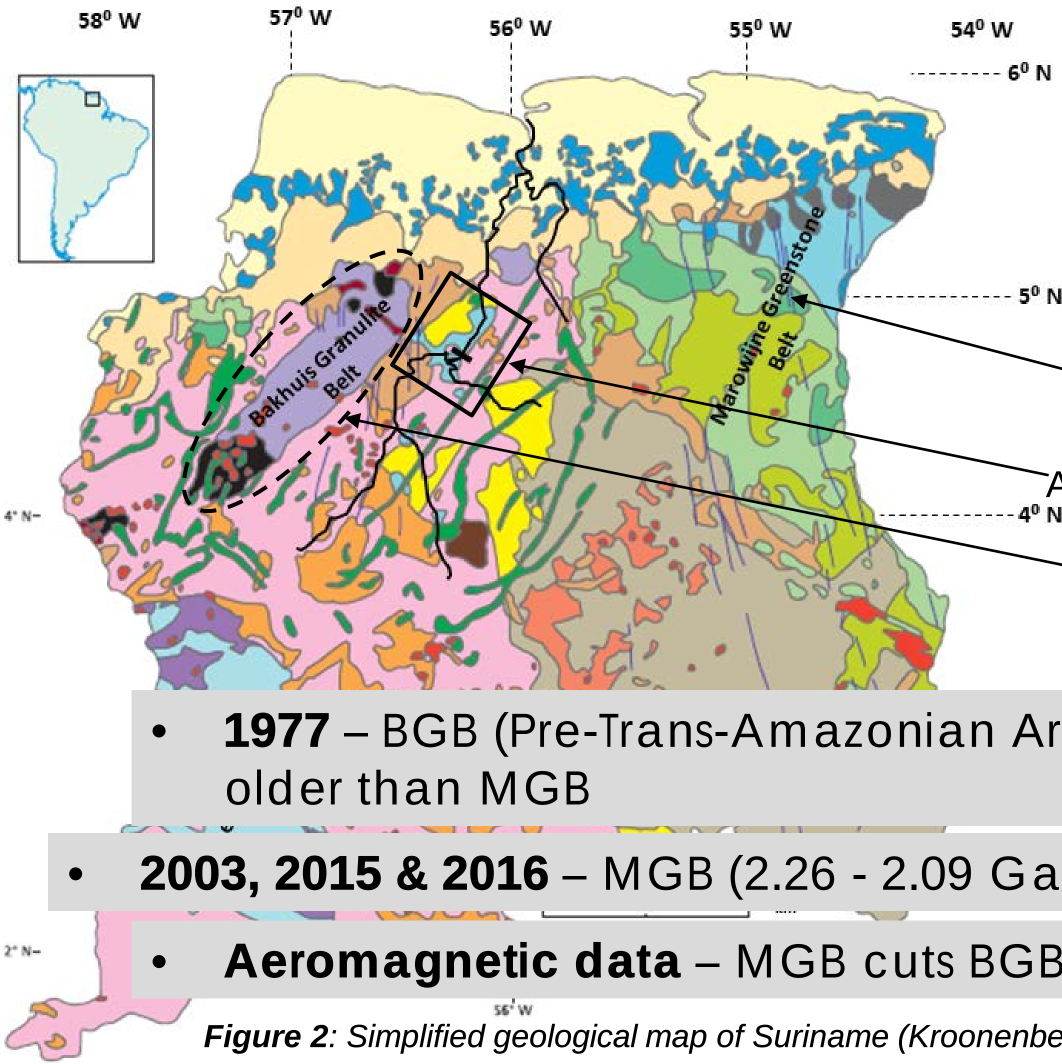


Figure 1: Simplified geological map of the Guiana Shield (Kroonenberg et al. (2016), compiled after various sources)



Marowijne Greenstone Belt (MGB)
(2.26-2.10 Ga)

Armina Formation along the Coppename River

Bakhuis Granulite Belt (BGB)
granulites, gneisses, charnockites
(2.08-2.05 Ga)

- **1977** – BGB (Pre-Trans-Amazonian Archean age 4.03 - 2.42 Ga) older than MGB
- **2003, 2015 & 2016** – MGB (2.26 - 2.09 Ga.) older than BGB (2.08 - 2.05 Ga)
- **Aeromagnetic data** – MGB cuts BGB in the north – BGB older

Figure 2: *Simplified geological map of Suriname (Kroonenberg et al. 2016)*

PROBLEM STATEMENT

"Are the Coppename metaturbidites deposited in an outlier and/or tectonically displaced basin of the same greenstone belt,

OR

whether they could be a part of the same trans-tensional basin in which the Bakhuis protoliths have been deposited, and only escaped from being incorporated in the part of the basin that suffered granulite-facies metamorphism?"

- Sedimentological, Petrographical and Geochronological characteristics of Armina Formation
- Plate tectonic setting of the turbidite basin

Facts about the Armina Formation

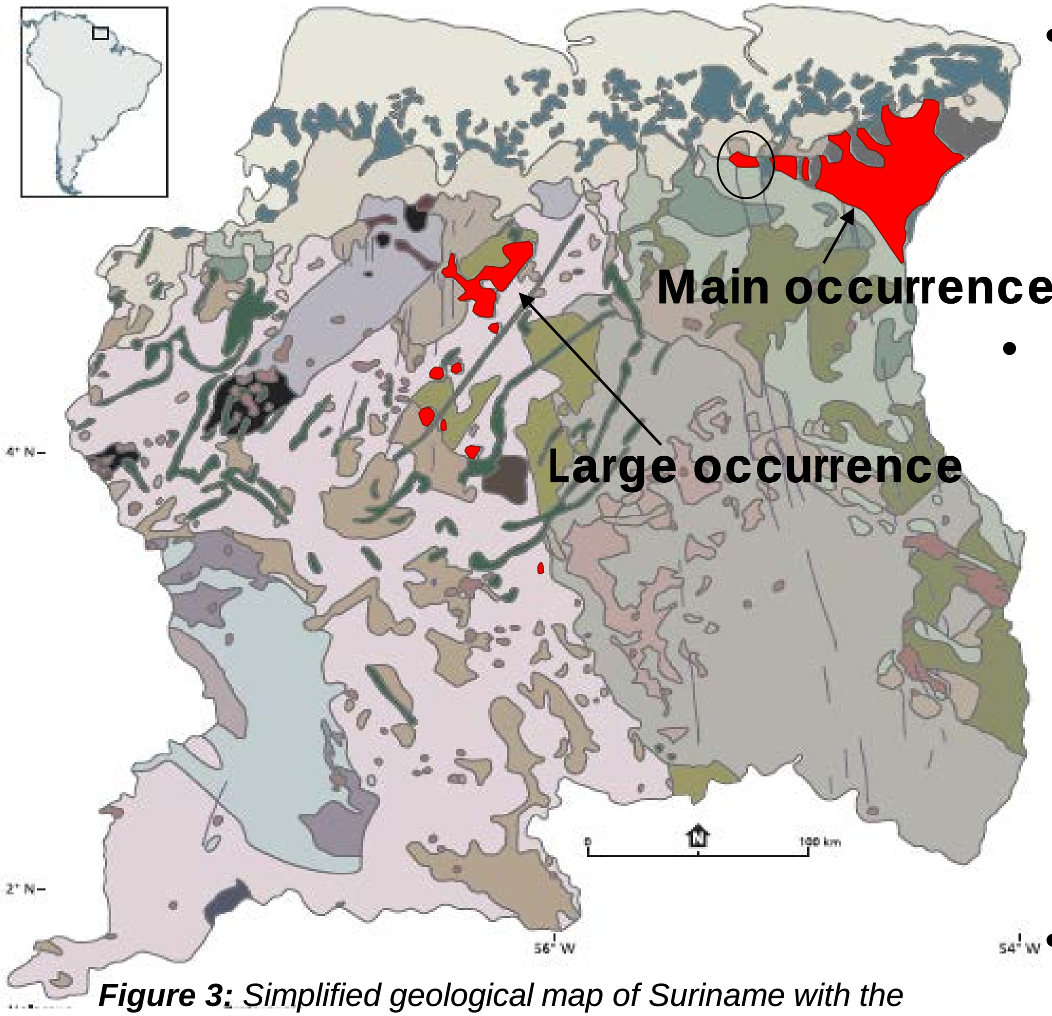


Figure 3: *Simplified geological map of Suriname with the occurrences of the Armina Formation, modified after Kroonenberg et al. (2016)*

- A thick clastic marine sequence with turbidite characteristics consisting of regularly alternating sequences of low-grade metagreywacke and phyllite
- Meta-sediments predominantly derived from erosion of associated Paramaka Formation volcanics
- Intruded by bi-mica and biotite granite bodies (Wonotobo)
- Deposited in an arc-trench depositional environment (Naipal, 2015), marginal basins (Daoust et al., 2011)
- Detrital zircons indicate max. age of 2127 ± 7 Ma for turbidite sequences in eastern Suriname

DATA ACQUISITION AND METHODOLOGY

Preliminary Research	
Literature	Thin sections

↓

Fieldwork along the Coppename River	
52 samples collected	Turbidite sequences measured

↓

Petrographical analysis	
25 samples	7 samples for point counting

↓

Geochemical analysis
12 samples for major (XRF) and trace element (LA-ICPMS) analysis

↓

Geochronological analysis (Uranium-Lead zircon dating)
6 samples (LA-ICPMS)

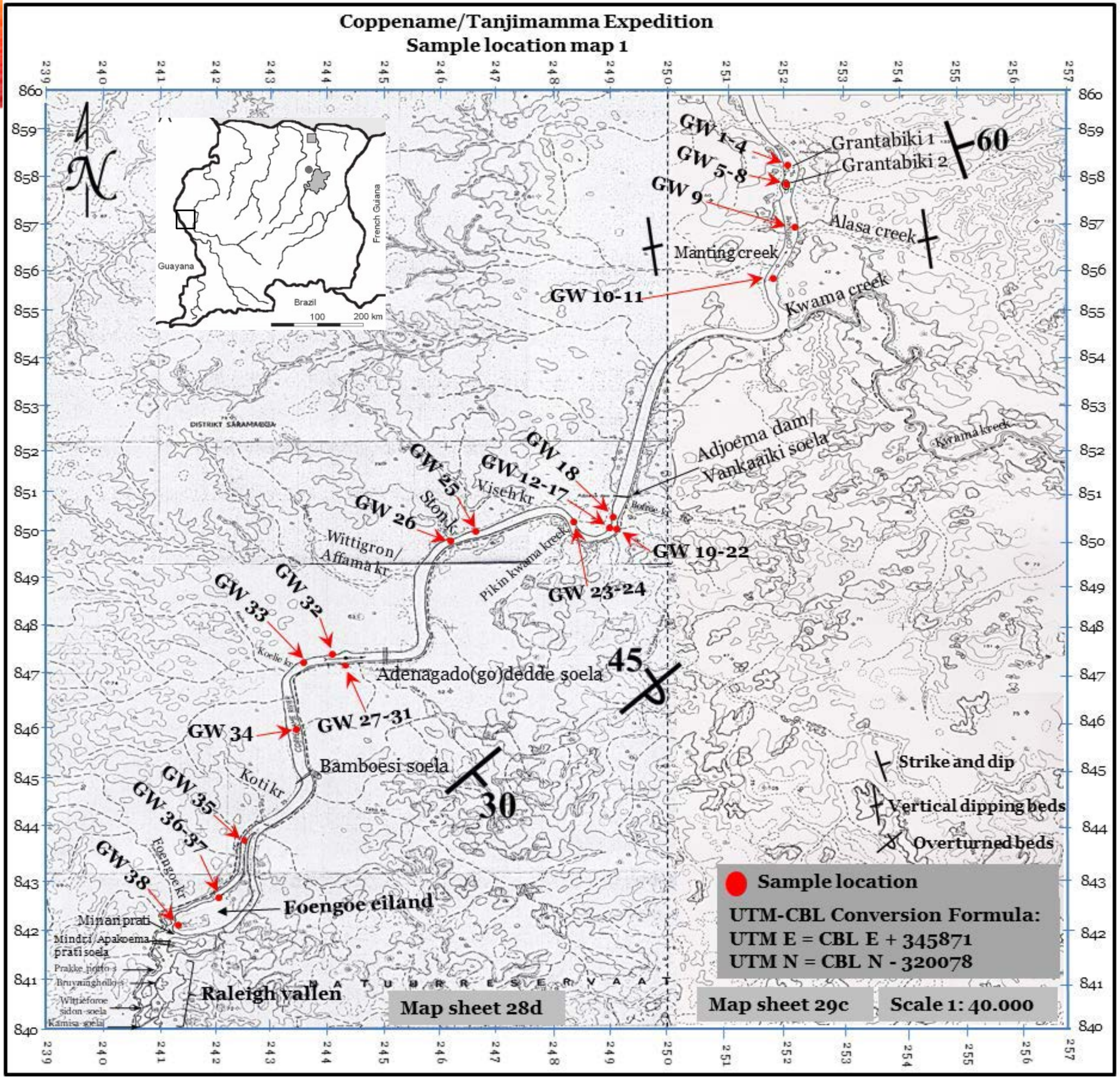


__Figure 4:__ Field map 1

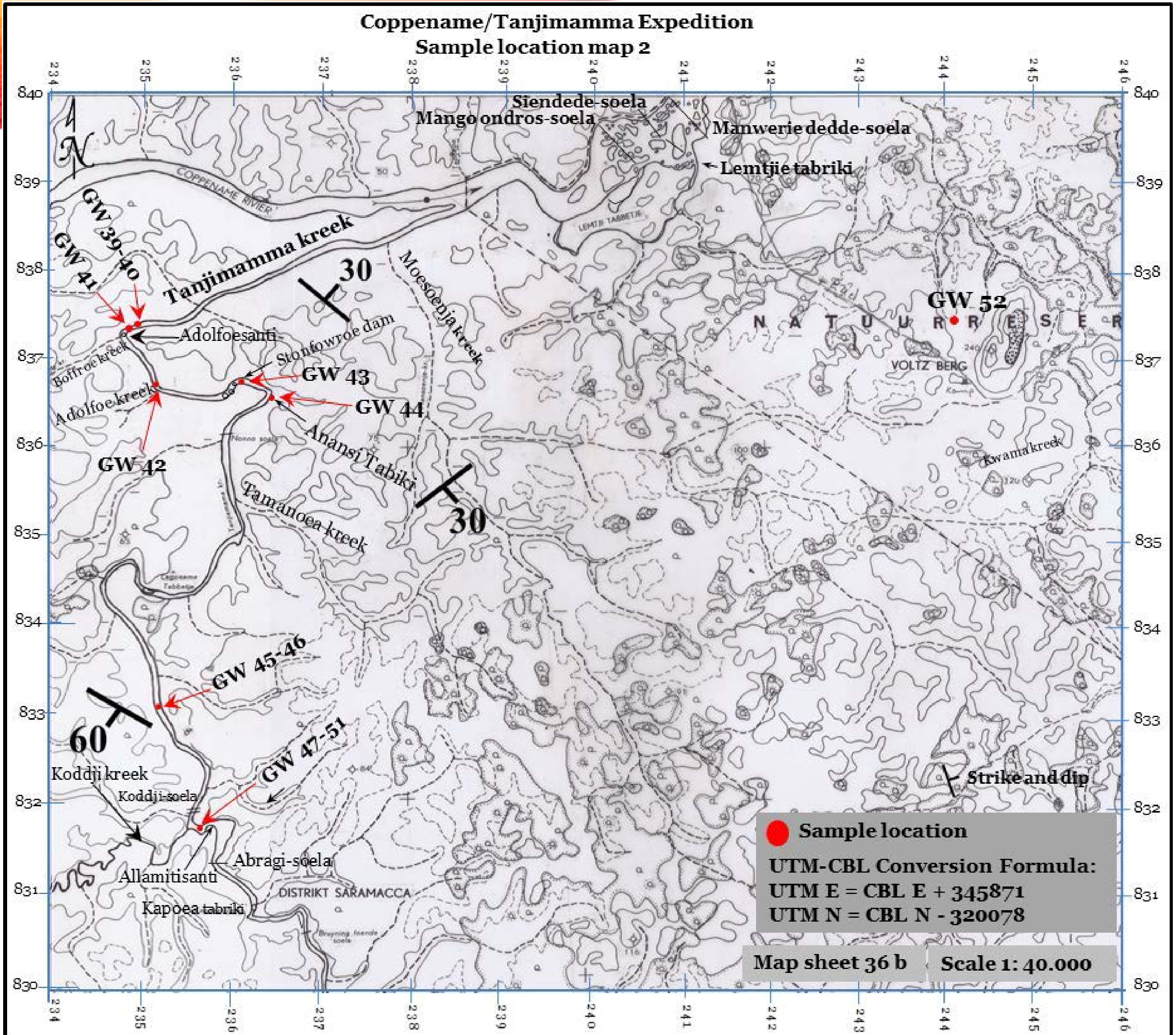


Figure 5: *Field map 2*

FIELD DATA

- The most extensive outcrops → Grantabiki in the north and along the Tanjimamma Creek in the south
- Turbidite sequences:

→ Thickness of continuous turbidite sequences → 1-5 m

→Alternation of 1) coarse grained greywacke beds with abundant quartz-veins (dm's) and

2) fine grained parallel laminated layers (cm's)

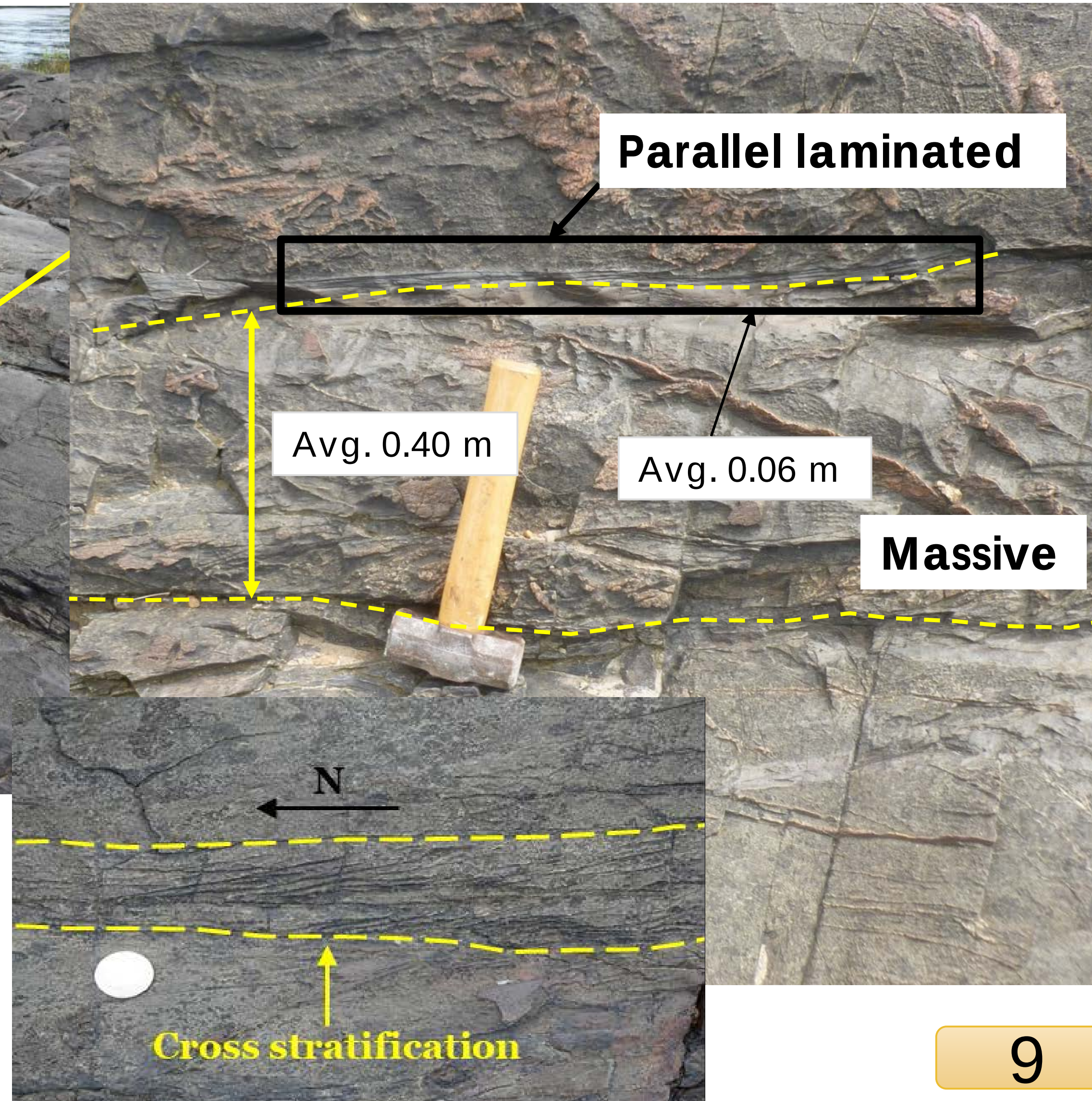
→ have undergone strong folding and jointing

Important observed characteristics:

- constant layer thickness,
- graded stratification in the coarser parts,
- small ripple-, wavy-, and convolute lamination and also cross stratification in the finer parts

FIELD DATA - GRANTABIKI

Figure 6: *7.4 m turbidite sequence of Grantabiki*



FIELD DATA - GRANTABIKI

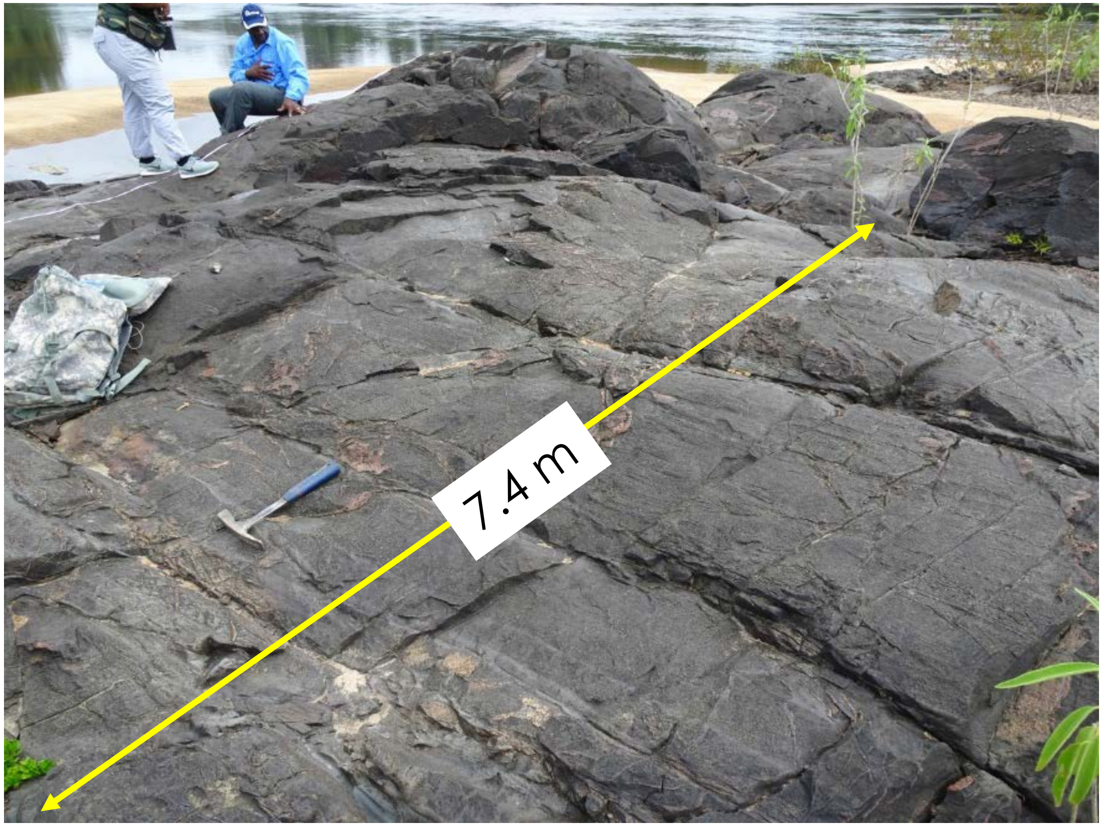


Figure 6: *7.4 m turbidite sequence of Grantabiki*

Orientation → N20°W, dipping 60° to the east (340,60E)

Others → N20°W, dipping vertical

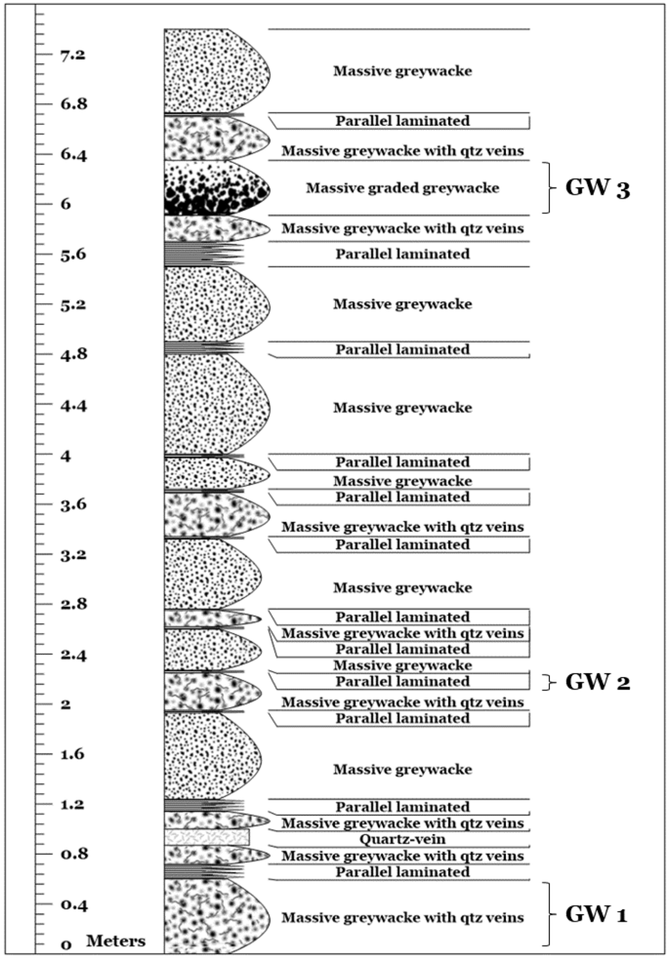


Figure 7*: Schematic view of 7.4 m turbidite sequence of Grantabiki*

4. FIELD DATA – TANJIMAMMA CREEK

- Thickness → discontinuous 11.71 m → 4 separate sections
- Same alternating layers, but also wavy lamination in fine parts
- Convolute lamination → loose blocks

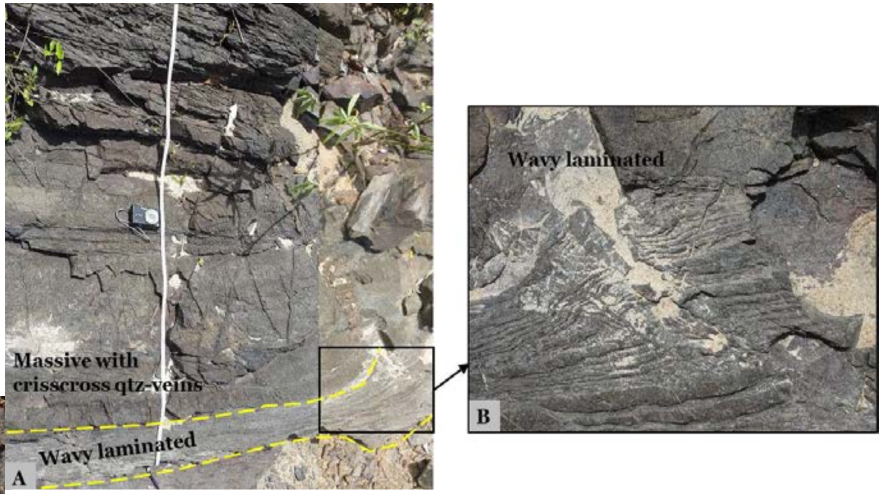


Figure 8: *Wavy laminated layer within the turbidite sequence along the Tanjimamma creek*

Orientation → N60°W, dipping 60° to the southwest (300,60SW)

Figure 9: *Convolute lamination*

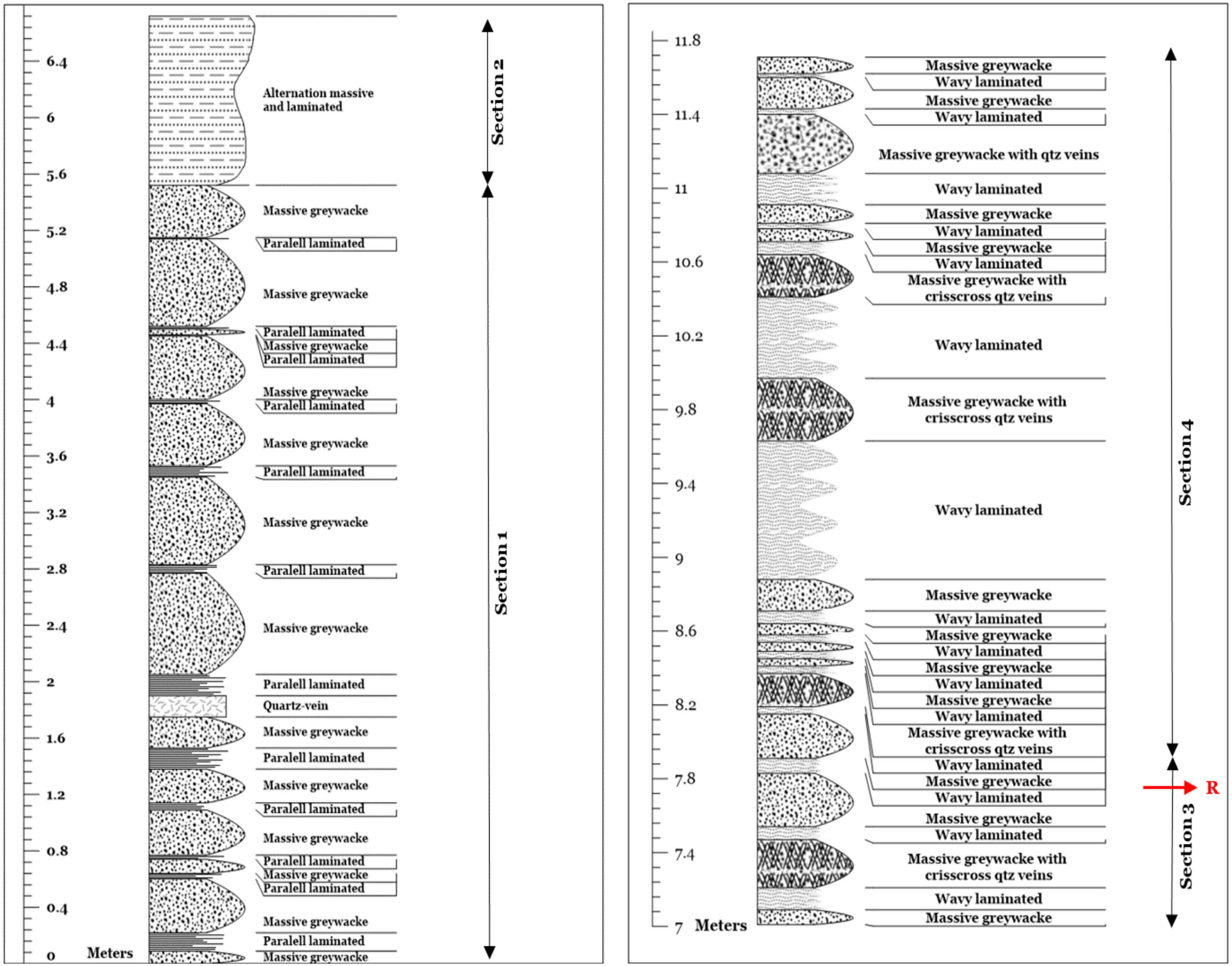
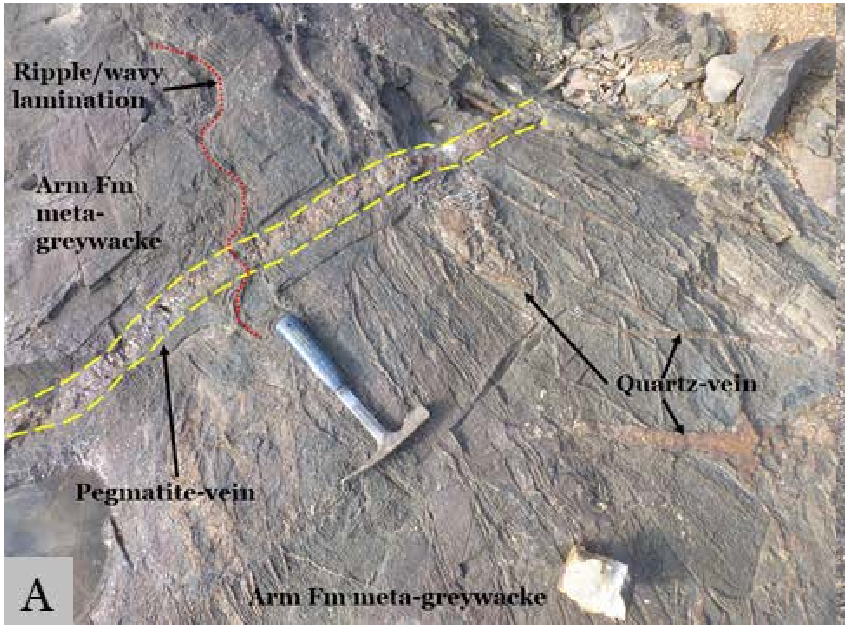


Figure 10: *Schematic view of the turbidite sequence along the Tanjimamma creek*

FIELD DATA:
VANKAAKI DAM



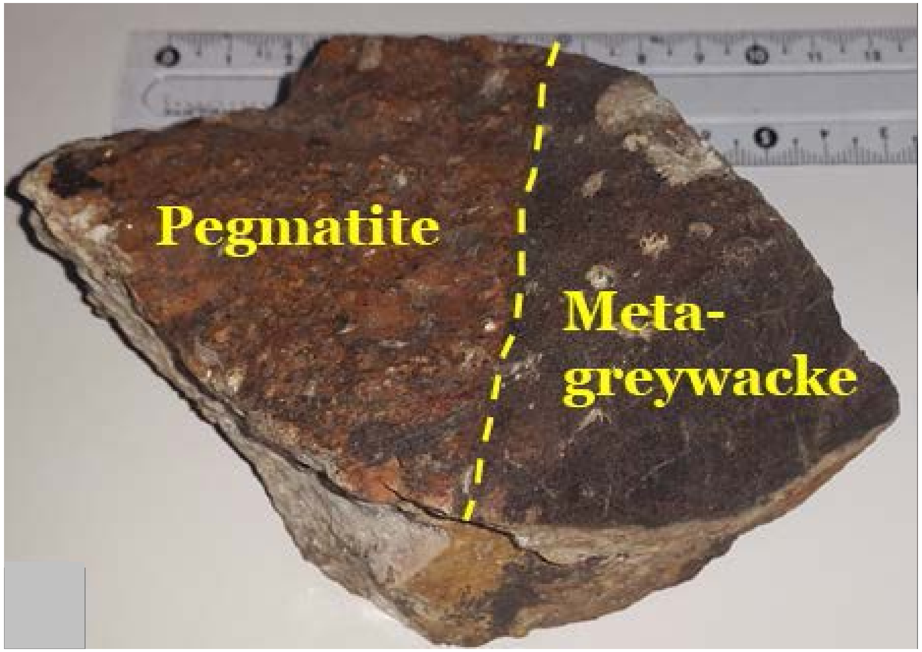


Figure 11: *Intrusive Vankaaiki Pegmatite*

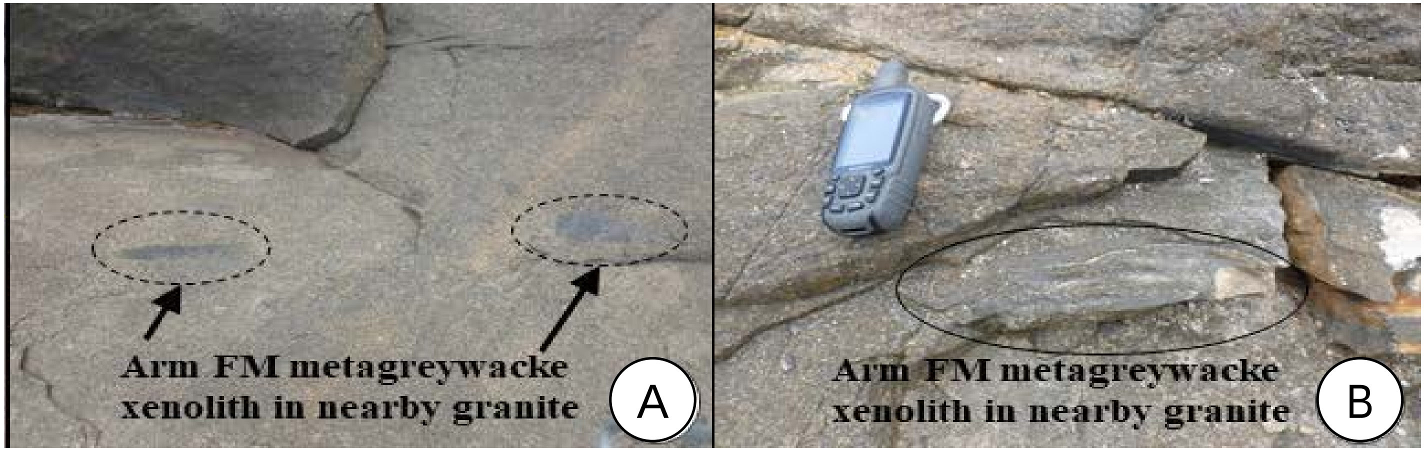


Figure 12: *Metagreywacke xenoliths in the nearby granite*

FIELD DATA:
ADENAGADO SULA & RALEIGH FALLS

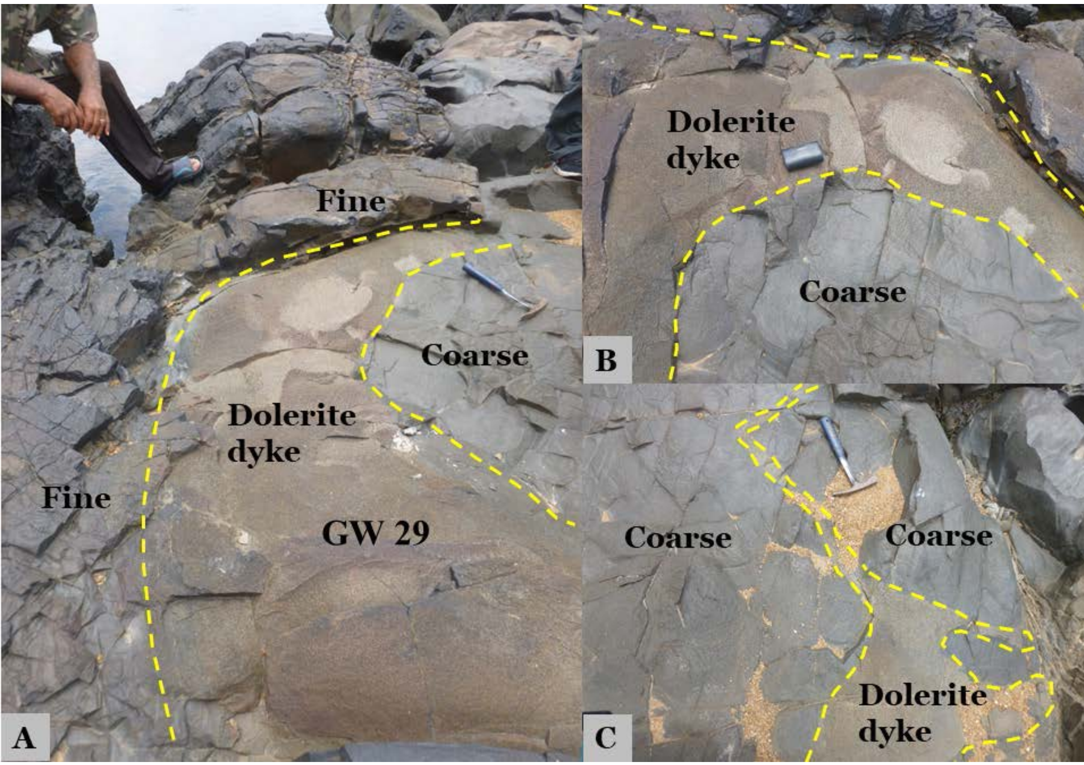


Figure 13: *Intrusive Adenagado sula dolerite*

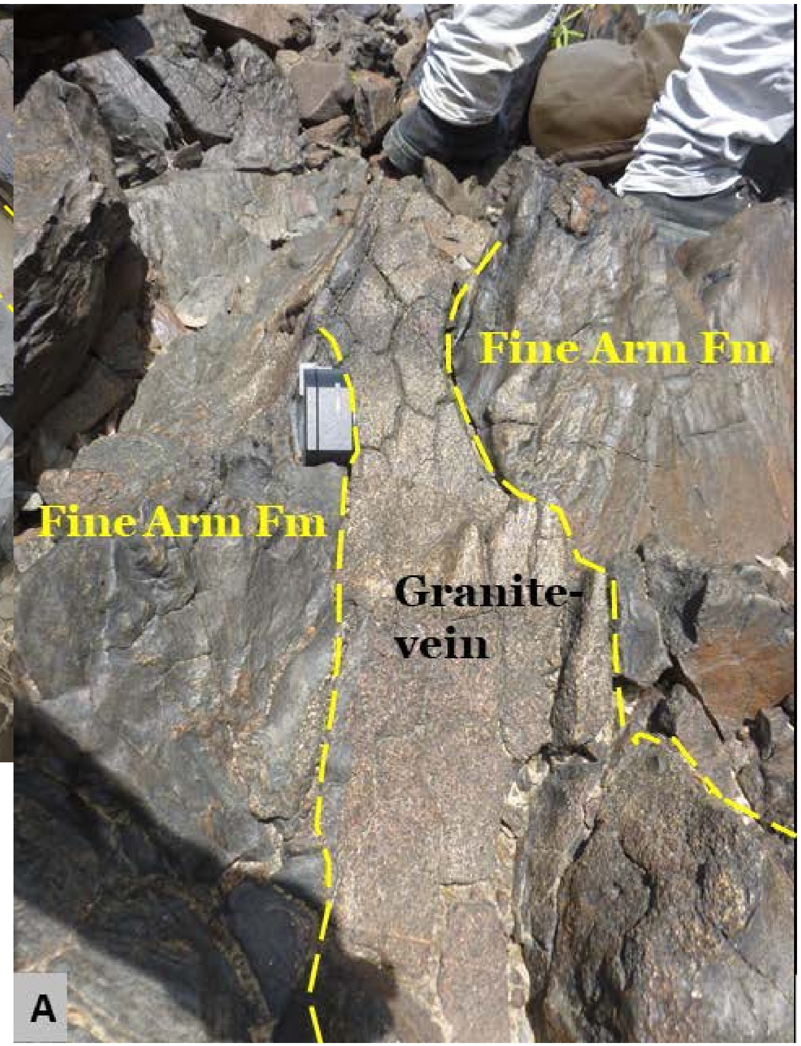


Figure 14: *Intrusive Raleigh Falls granite*

PETROGRAPHY

- The metagreywackes of this area:
  - Fine - very coarse-grained
  - consisting of
    - **quartz, plagioclase, K-feldspar (including microcline), biotite, muscovite**, chlorite, epidote, allanite, rutile, zircon, tourmaline, titanite, magnetite/ilmenite, pyrite/other sulfide mineral, and
    - igneous (both plutonic and volcanic), metamorphic and sedimentary lithic fragments → in coarse sections
  - The plutonic fragments → probably derived from TTG plutons due to the abundance of plagioclase relative to alkali feldspar.

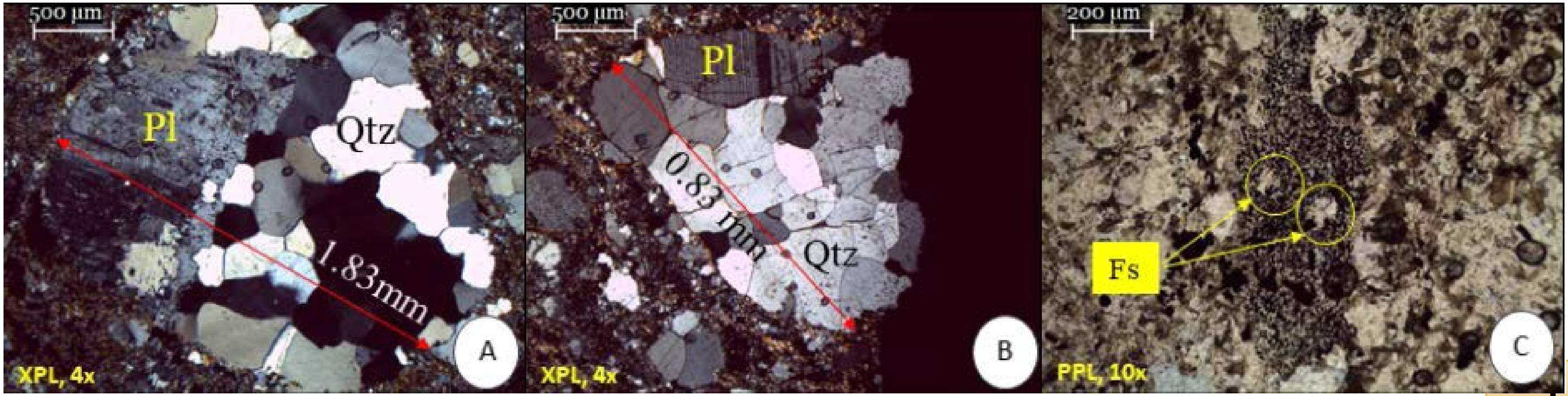


Figure 15: *Plutonic and Volcanic lithic fragments*

PETROGRAPHY

Modal analysis (point counting):

- GW 3 – lithic wacke, all others – feldspathitic wacke
- GW 46 pelitic rock
- From north to south - texturally and mineralogical immature to sub-mature

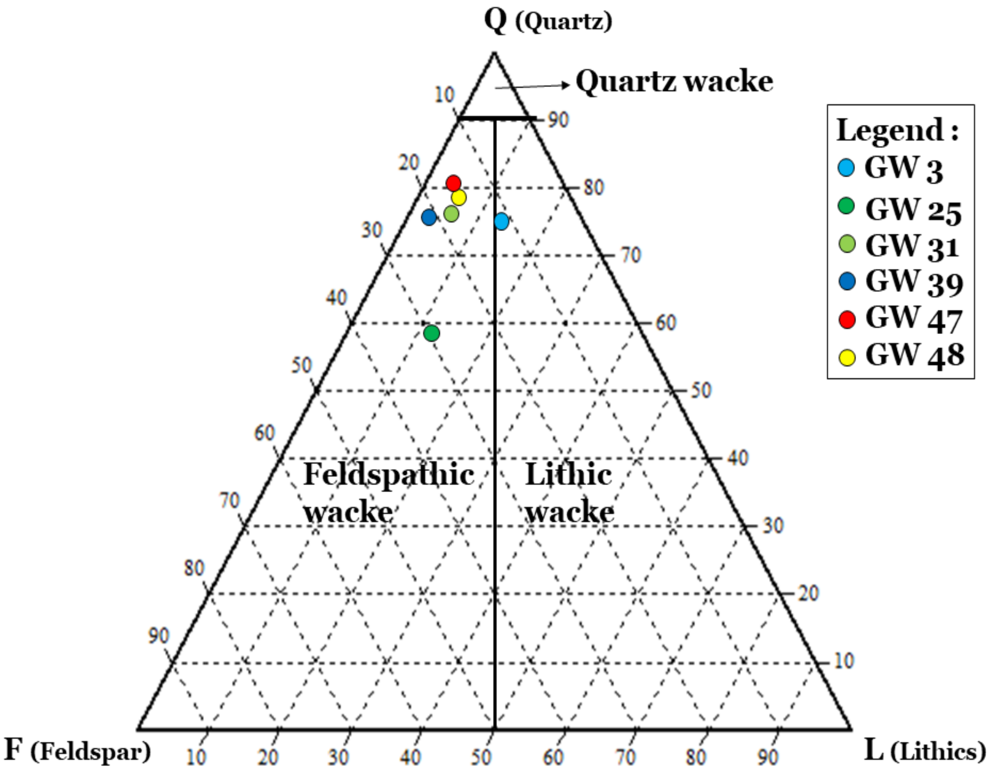


Figure 16: *Modal analysis of 6 metagreywacke samples*

PETROGRAPHY

- Provenance analysis (assess through point counting)
  - QFL & QmFLt provenance diagrams → greywackes with a volcanic provenance in the north at Grantabiki were deposited in an active island arc, whereas from Adenagado sula southwards the rocks become more arkosic with a more granitic provenance deposited in an active continental margin

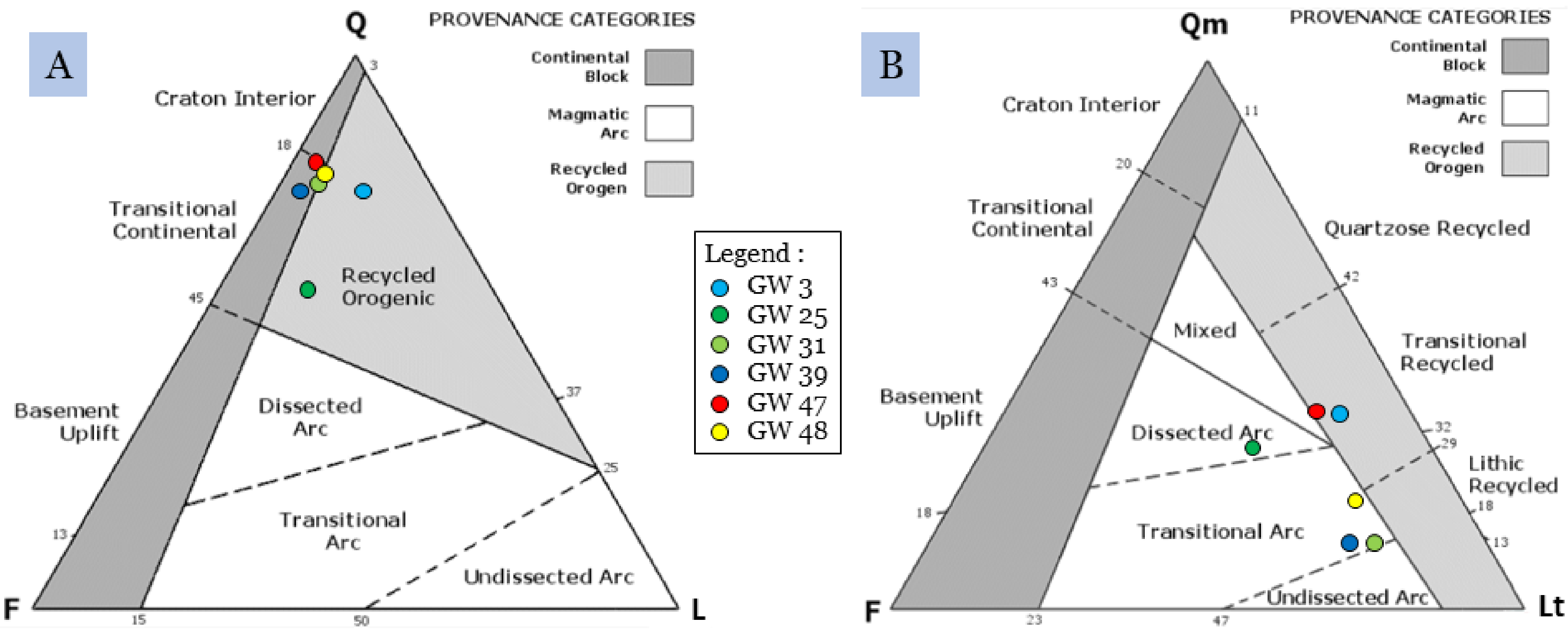


Figure 17: *Provenance discrimination diagrams: QFL and QmFLt after Dickinson et al, 1983*

METAMORPHISM

- The mineral assemblages indicate:
  - **regional metamorphism** from greenschist facies (chlorite and biotite zone) to lower amphibolite facies (garnet zone),
  - whereas in the vicinity of granitoid rocks **contact metamorphism** occurred.

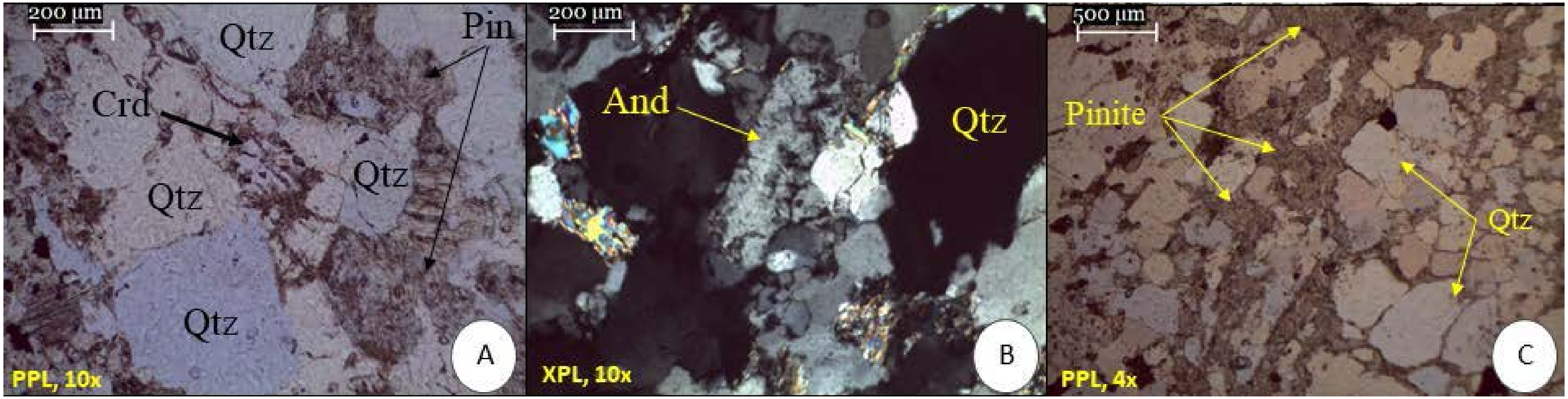


Figure 18: *Contact metamorphic minerals and alteration products*
Crd = CORDIERITE

GEOCHEMISTRY

- **Geochemical composition indicates:**

- Northern samples → greywackes

- Southern samples → arkose

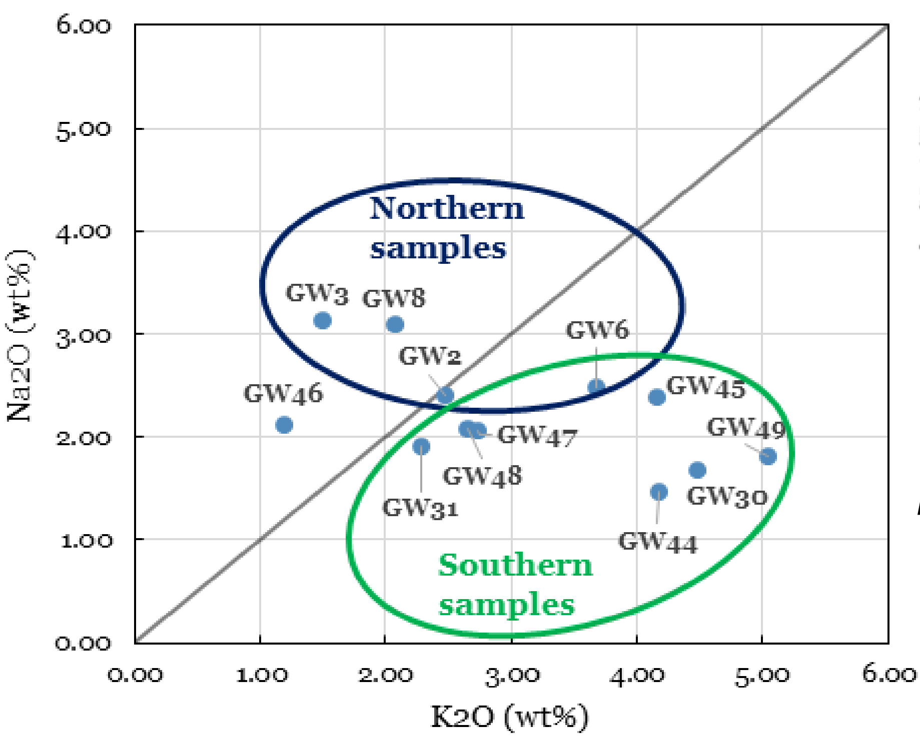


Figure 19: *Correlation plot of K2O and Na2O*

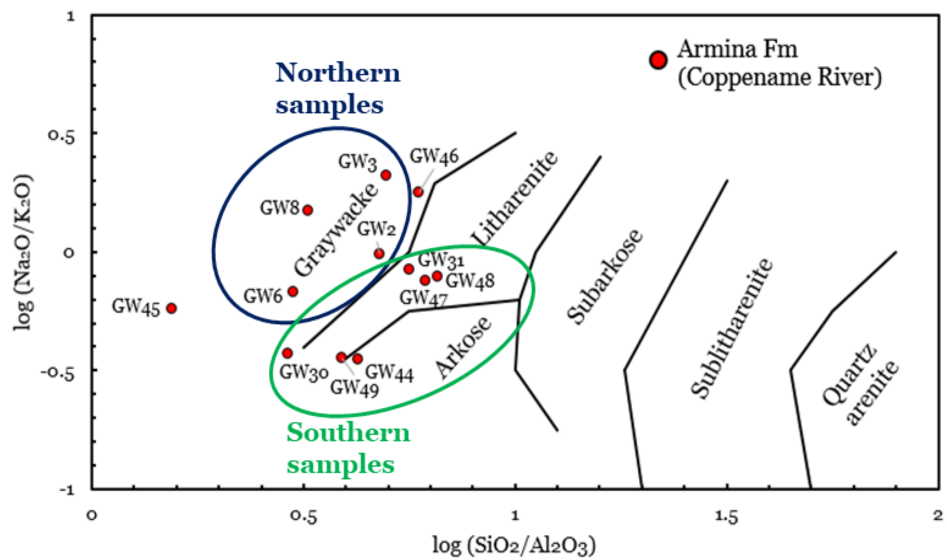


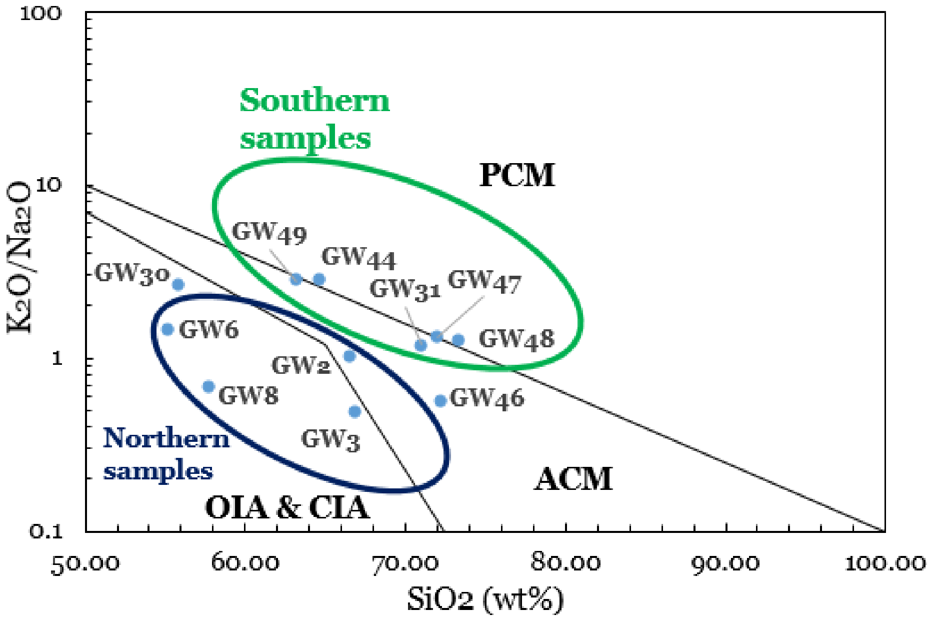
Figure 20: *Classification plot after Pettijohn et al., 1972*

GEOCHEMISTRY

- **Tectonic setting:**

- Northern rocks → deposited within an active island-arc (oceanic and continental),

- Southern rocks → deposited in an continental margin related to a felsic igneous provenance



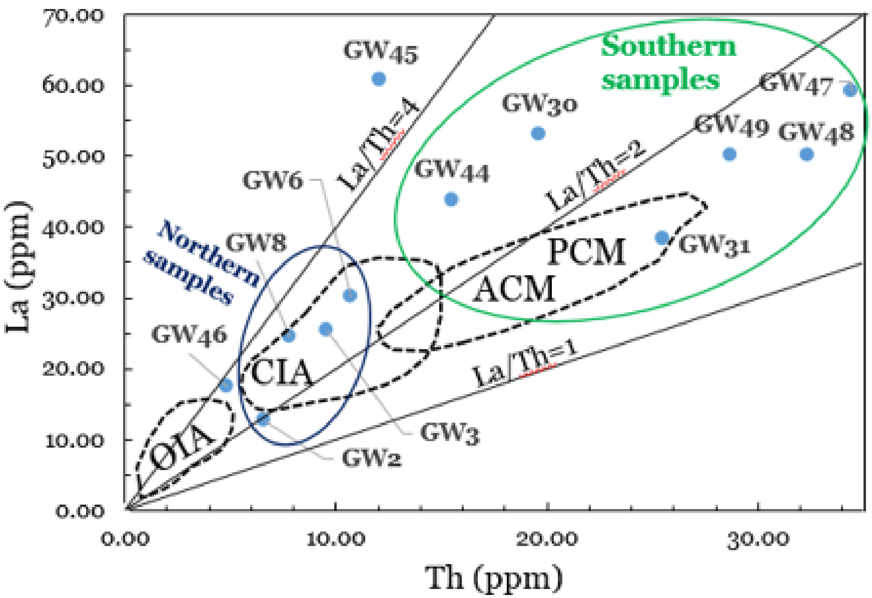


Figure 21: *Tectonic setting discrimination diagram after Roser & Korsh, 1986 and Bhatia, 1986*
OIA *= Oceanic Island Arc;* ***CIA*** *= Continental Island Arc;* ***ACM*** *= Active Continental Margin;*
PCM *= Passive Continental Margin*

GEOCHEMISTRY

- **Trace element concentration also point to different provenance:**

- Higher Ni concentrations in the northern samples → a partly mafic igneous provenance (volcanic), while
- Higher Th and U concentrations in the southern samples suggest a more felsic igneous provenance (granitic).

GEOCHRONOLOGY

- Detrital zircons in the Armina Formation → **2162 ± 30 Ma** for the major sediment source of the metaturbidites sequence in the Coppename area

- Younger granites intruding the Armina metaturbidites:
  - → 2005 Ma (Voltzberg granite),
  - → 2004 Ma (Raleigh Falls granite),
  - → 1990 Ma (Vankaaikisula granite)

INTERPRETATIONS

- The Armina Formation rocks along the Coppename River were deposited in 1-5 m thick fining-upwards (towards the north) turbiditic sequences → characterised by constant layer thickness, graded stratification in the coarser parts, small ripple-, wavy-, and convolute lamination and also cross stratification in the finer parts.
- Two generations of intrusives granitoid rocks in Armina Formation of the Coppename area.
  - Relatively older intrusion indicated by the plutonic fragments in the metagreywacke.
  - Younger granite intrusion evidenced by pegmatite veins, contact metamorphism in the metagreywackes, and metagreywacke xenoliths in the granite.
    - Ages of younger intruding granites are slightly higher than most Wonotobo granites in Western Suriname.

INTERPRETATIONS

- Petrographical and geochemical analysis as well as individual trace elements → greywackes with a volcanic provenance in the north were deposited in an active island-arc, whereas from Adenagado soela southwards the rocks become more arkosic with a more granitic provenance deposited in an active continental margin.

- Detrital zircons indicate a similar age as that of the eastern Marowijne Armina Formation

- No zircons in Bakhuis age range (2.08-2.05 Ga) have been found in the Armina metagreywackes of the Coppename area, and no granulite clasts or other typical minerals such as orthopyroxene and meso-perthitic feldspar have been found either.

CONCLUSIONS

Explanation regarding the different provenances within the Armina Fm:

- Probably due to the development of the arc over time, the bottom of the sequence is more volcanic while still an island arc (north), whereas higher in the sequence more granitic when it has already become an active continental margin due to the development of the subduction zone (south) OR
- The turbidites in the north and south were fed by different river systems and the two sequences lay next to each other on the same level

CONCLUSIONS

- The turbidite deposits of the Armina formation show no affinity to the Bakhuis rocks and are a part of the same greenstone belt of northeastern Suriname deposited on the fore-arc side in an arc trench environment.
- There is no evidence that the Bakhuis Granulite Belt already existed when the Armina Formation was deposited HOWEVER,
- The presence of inherited zircons with ages between 2120 and 2150 Ma in the sillimanite gneisses of the Bakhuis Belt might indicate that the Bakhuis granulites could represent the high-grade equivalents of the Armina metaturbidites, and hence share the same provenance area.

For more information, please contact me:

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