



The importance of gold timing in West-Africa: Examples from the Ashanti and Oumé- Fettèkro Belts

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Presentation Content

Regional Geology of the West-African Craton

Geology, Structural Settings and Gold Deposit Types of the Southern Ashanti Belt

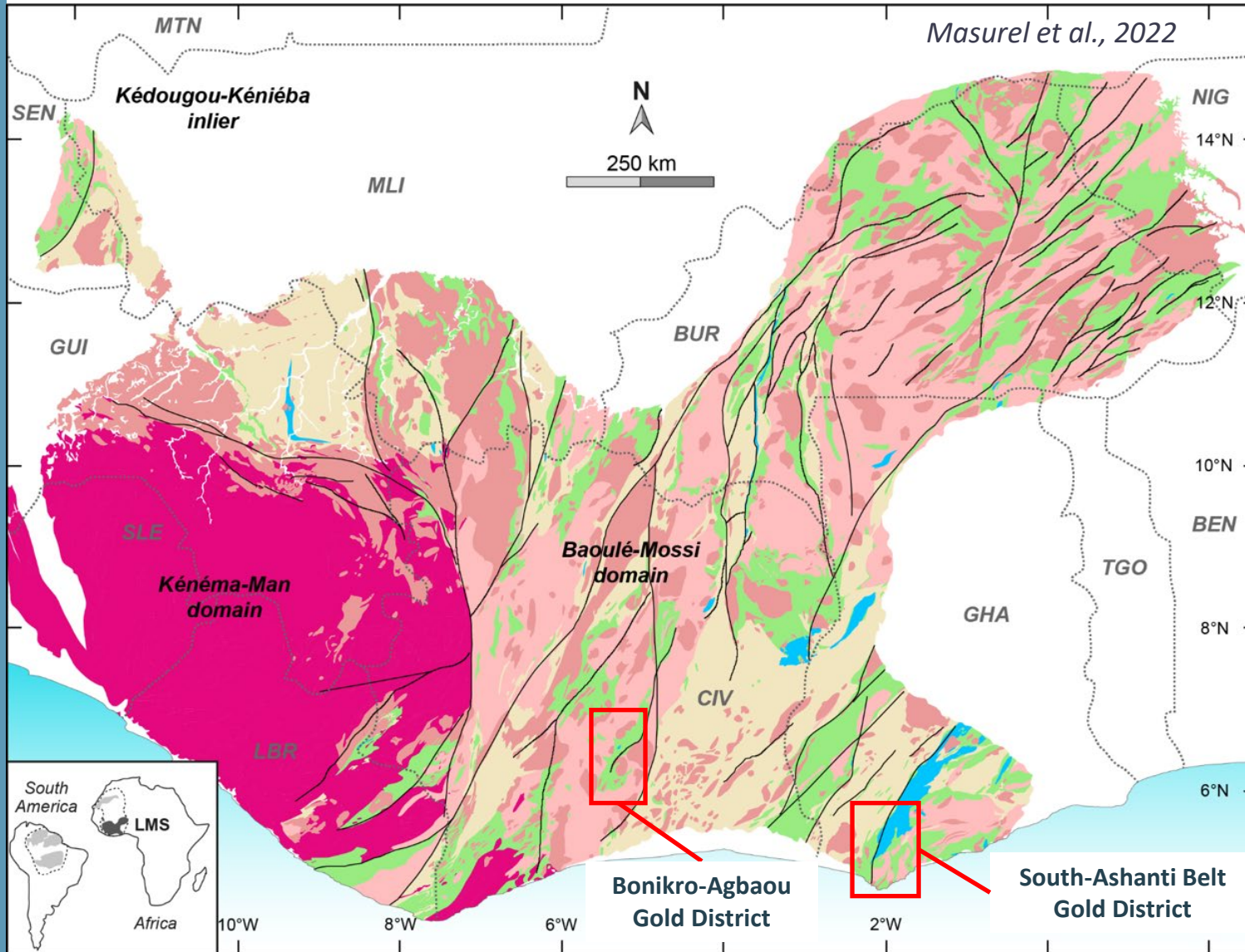
- Sedimentary Hosted Graphitic Shear Zones
- Fault Fill Quartz Veins
- Paleoplacer
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- Fault controlled Extensional Vein system
- Folded Veins System

Geology, Structural Settings and Gold Deposit Types of the Oumé-Fettèkro belt

- Intrusive Hosted Gold Deposits
- Intrusive Related Gold Deposits (IRGD)
- Late Brittle Gold Deposits
- Foliation Parallel Vein System

Gold Endowment of the Belts and Deposits Timings

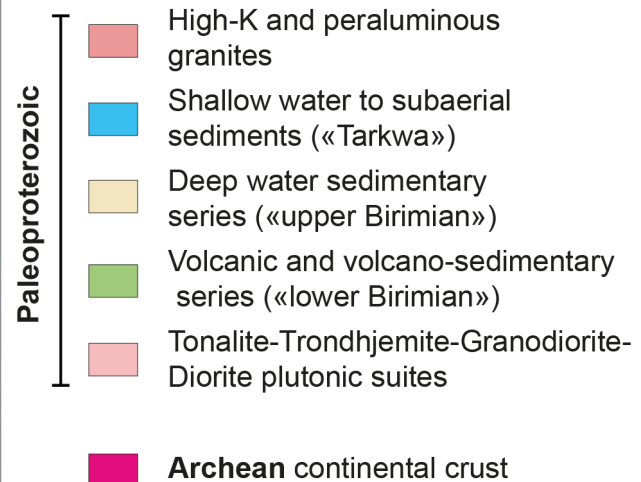
Regional Geology – West African Craton



Geology of the West African Craton

This slide shows the geology of the West-African craton, the red portion in the left corner is the Archean portion of the craton, the remainder of the craton is composed of Birimian age sequences with volcanic belts in green, flysch type basins in beige and fluvial Tarkwaian type basins in blue.

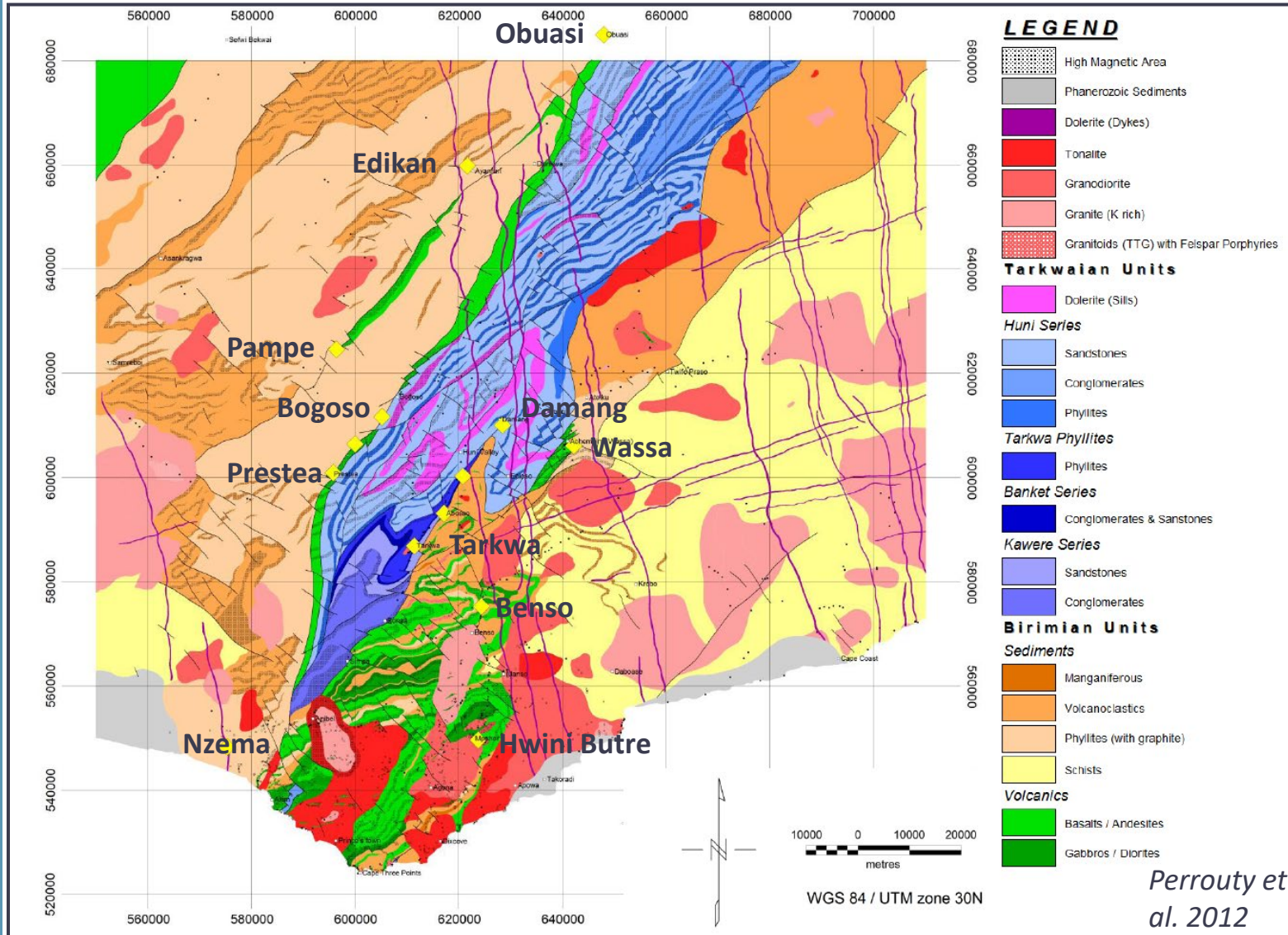
The red squares represents the southern portions of the Ashanti and Oumé-Fettèkro belts for which we will review all the major deposits, their structural settings as well as the timing of gold mineralization.





Geology and Structural Settings of the Southern Ashanti Belt

Regional Geology - The Ashanti Belt



Geology of the Ashanti Belt

The geology map is from Perrouy 2012 which was published from work conducted during the West African Research Initiative (WAXI) phase 2.

To the West of the Ashanti belt is the Kumasi Sedimentary Basin and to the East of the Belt, the Akyem sedimentary basin.

The Ashanti belt itself is mostly composed of volcanic rocks to the south and along the Ashanti trend on the western side of the belt, the central portion of the belt is made of the shallow Tarkwaian sedimentary basin.

Ashanti Belt Magnetic & Cross Section

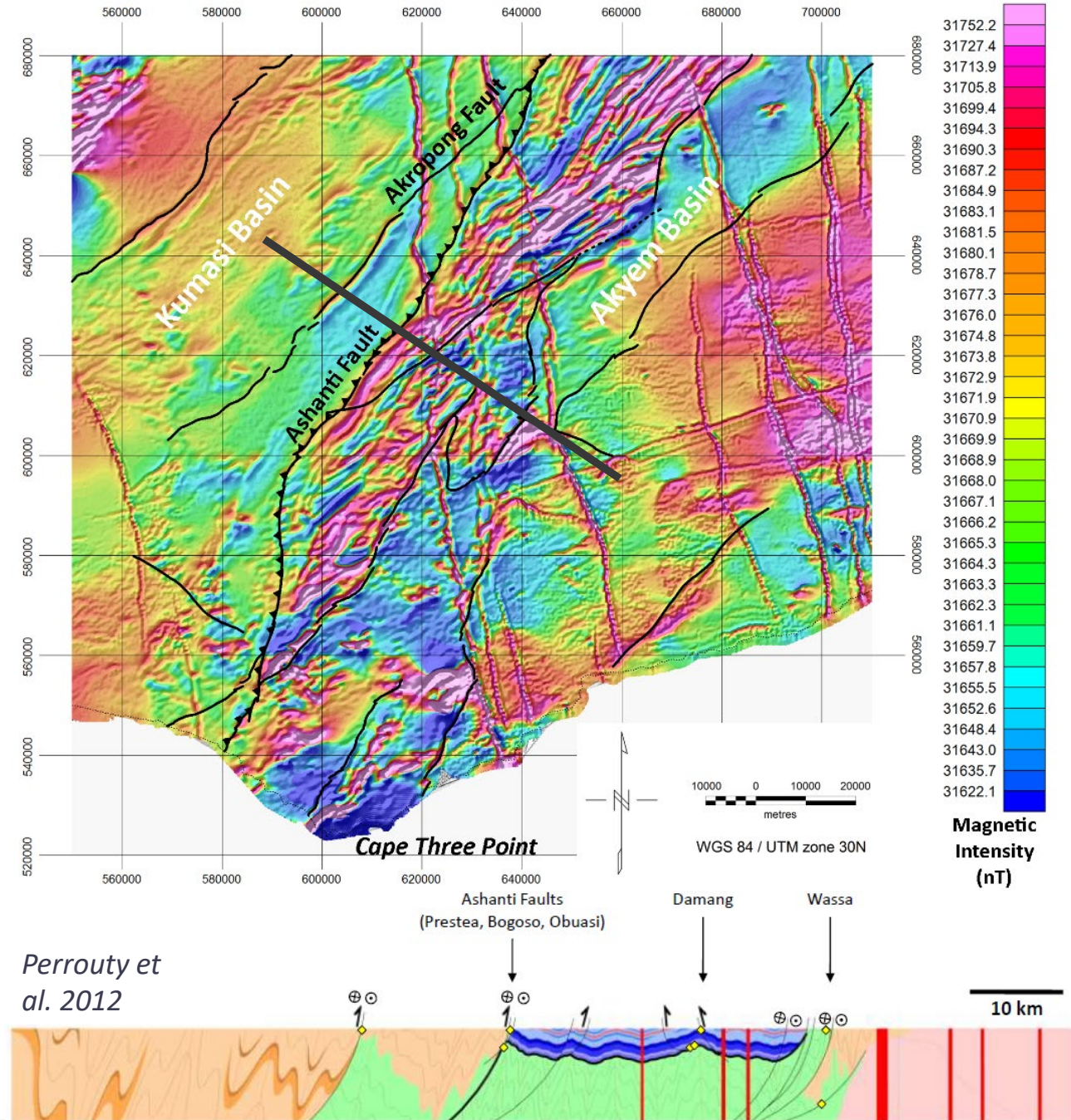
Magnetic Signature of the Belt

The magnetic map shows the main structural lineaments of the belt as well as the location of the cross section.

The Birimian age basins are characterized by magnetic low signatures while the volcanic sequences are magnetic high.

The Tarkwaian basin in the center of the belt is shallow, and you will notice the principal structures all dipping to the North-West.

The cross-section starts West in the Kumasi basin before crossing the Akropong Fault and the Ashanti Fault and ending in the granitoids East of the Wassa volcanic sequence.



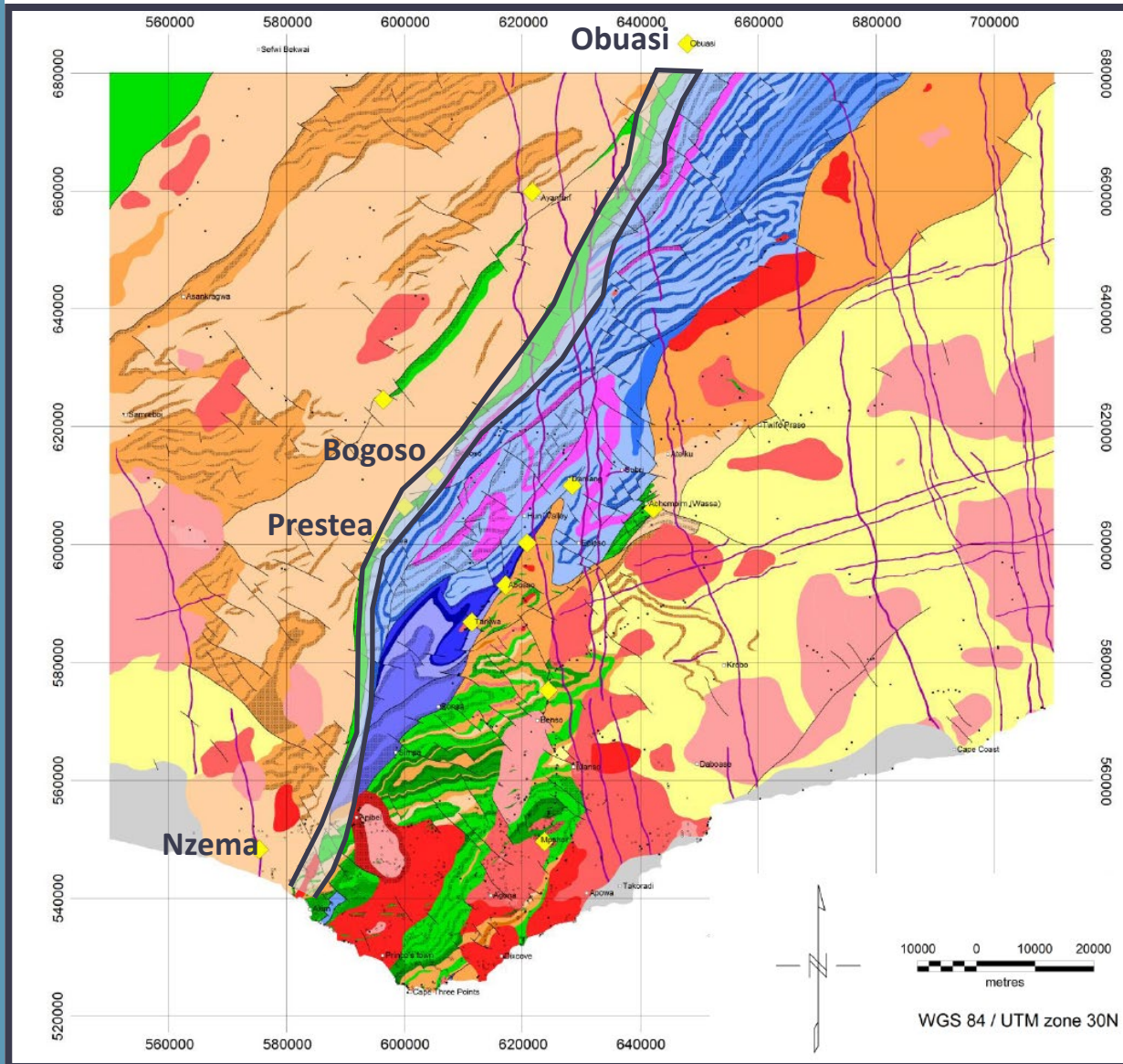
Structural Settings of The Ashanti Belt

Regional Interpretation (This Study)		In Birimian <i>Bogoso / Obuasi</i> (Allibone et al., 2002)	In Tarkwaian <i>Damang</i> (Tunks et al., 2004)	Regional (Eisenhor et al., 1992)	Regional (Feybesse et al., 2006) (Milesi et al., 1992)
Eoeburnean > 2150 Ma	Early Birimian stratigraphy	Volcanism Granitoids intrusion Regional metamorphism		Birimian sediments and volcanics penecontemporaneous Plutonism (Dixcove type granitoids)	Magmatic accretion Plutonism Birimian sedimentation
	D1, N-S shortening Regional scale folding in the Early Birimian unit Syn-tectonic plutonism before 2170 Ma Possible gold mineralization				
D2, Extension Phase Late Birimian sedimentation S2 parallel to bedding (S0) in Birimian sediments Tarkwaian basin controlled by detachments as the early Ashanti fault		D1 S1 parallel to bedding Flat-lying bedding parallel shearing		Onset of deformation in a "foreland thrust" and Tarkwaian deposition	D1, NW - SE shortening Thrust faults Tarkwaian sediments deposition (Syn D1) Metamorphism (6 kbar / 550 - 650 °C)
Eburnean 2120 - 2060 Ma	D3, NW-SE shortening Km scale folds in Birimian and Tarkwaian S3 subvertical crenulation cleavage NE-SE Thrust faults (Ashanti, Damang, ...) Peak of metamorphism (Low Amphibolite)	D2, NW-SE shortening Isoclinal folds with axial surface parallel to the regional faults and shear zones Ashanti thrust fault	D1, NW-SE shortening Km scale folds (with subvertical axial surface (S1)) Damang thrust fault	D1, NW-SE shortening S1 (NE-SE) subvertical and subparallel to bedding in both Birimian and Tarkwaian Regional folds (tight to isoclinal)	D2/D3, NW-SE shortening Tarkwaian folds Strike-slip faults and shearing Gold mineralizations Metamorphism (2 - 3 kbar / 200 - 300 °C)
	D4, NNW-SSE shortening Sinistral shear reactivation of D3 thrust S4 crenulation cleavage ENE-WSW Greenschist retrograde metamorphism Remobilization and concentration of gold particle along the shear zones and at the base of Tarkwaian	D3 Low dip axial surface fold at Obuasi S3 crenulation cleavage overprinting S2 Final stage of D2 ?		D2, Continuing compression S2 (NE-SE) fabrics overprint S1 foliation S2 is defined by aligned muscovite and elongate recrystallised quartz grains Metamorphism	
	D5 Recumbant folds (< m) Subhorizontal crenulation cleavage Last pyrite/gold mineralization associated with quartz vein	D4, NNW-SSE shortening Hm scale fold at Obuasi	D2, NNW-SSE shortening Thrust faults and minor folds	Syn-tectonic plutonism (Cape-Coast type granitoids)	
	D6, NE-SW shortening, Panafrican (600 Ma) ?? Low amplitude folds + crenulation cleavage ≈ N320 / 70 (RH) Reverse faults oriented NW-SE	D5 or syn-D4 Sinistral strike-slip faults and shearing Gold mineralization	D3, ESE-WNW shortening Folds with shallowly dipping axial surfaces and mineralized quartz veins, post-dating the peak of metamorphism	K-rich plutonism (cross-cutting all previous structures)	Late plutonism <i>Perrouy et al. 2012</i>
			D4 Faults oriented NW-SE		



Deposit Types of the Southern Ashanti Belt Based on Litho- Structural Contexts

Sedimentary Hosted Graphitic Shear Zones



Deposit characteristics

The first type of deposit are sedimentary hosted shear zones which occur along the Ashanti trend and include Bogoso, Obuasi, Prestea and Nzema.

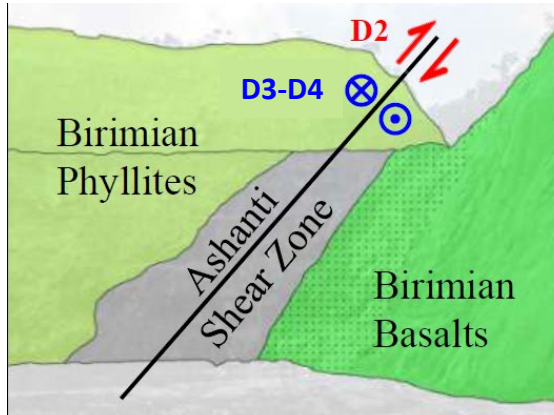
Mineralization in these deposits is characterized by disseminated sulphides along shear fabrics and quartz vein boudins. The dominant sulphide assemblage is Arsenopyrite-Pyrite with the Arsenopyrite generally being associated with the gold, by and large, these deposits are refractory.

Deposits are characterized by a strong penetrative shear fabric, hosted mainly in Carbonaceous Birimian age sedimentary basin (Flysch Sequence).

Quartz veins are sparse and have been boudinaged and transposed along the shear fabric.

Bogoso-Obuasi-Prestea-Nzema (Salman Trend).

Sedimentary Hosted Graphitic Shear Zones



Sedimentary Hosted Graphitic Shear Zones - Deformation

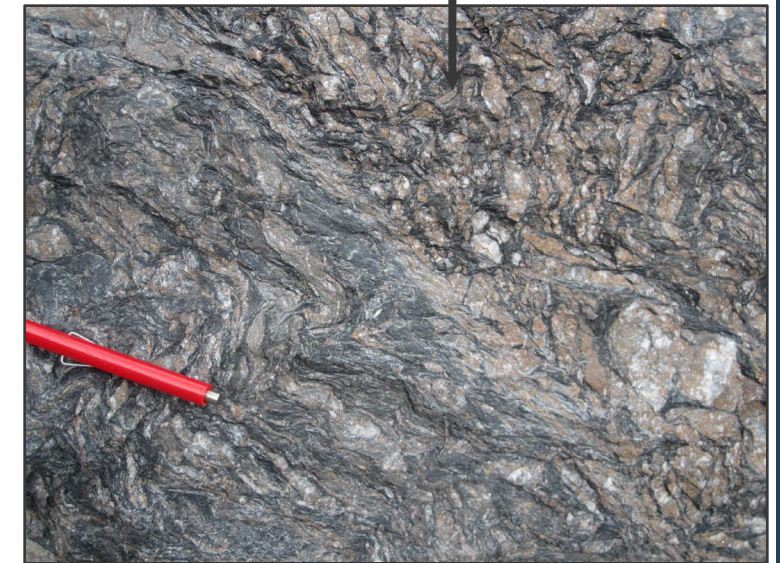
Main characteristics of Deposits

Progressive ductile deformation of the Birimian age flysch sequence found in the hanging wall of the Bogoso and Prestea deposits.

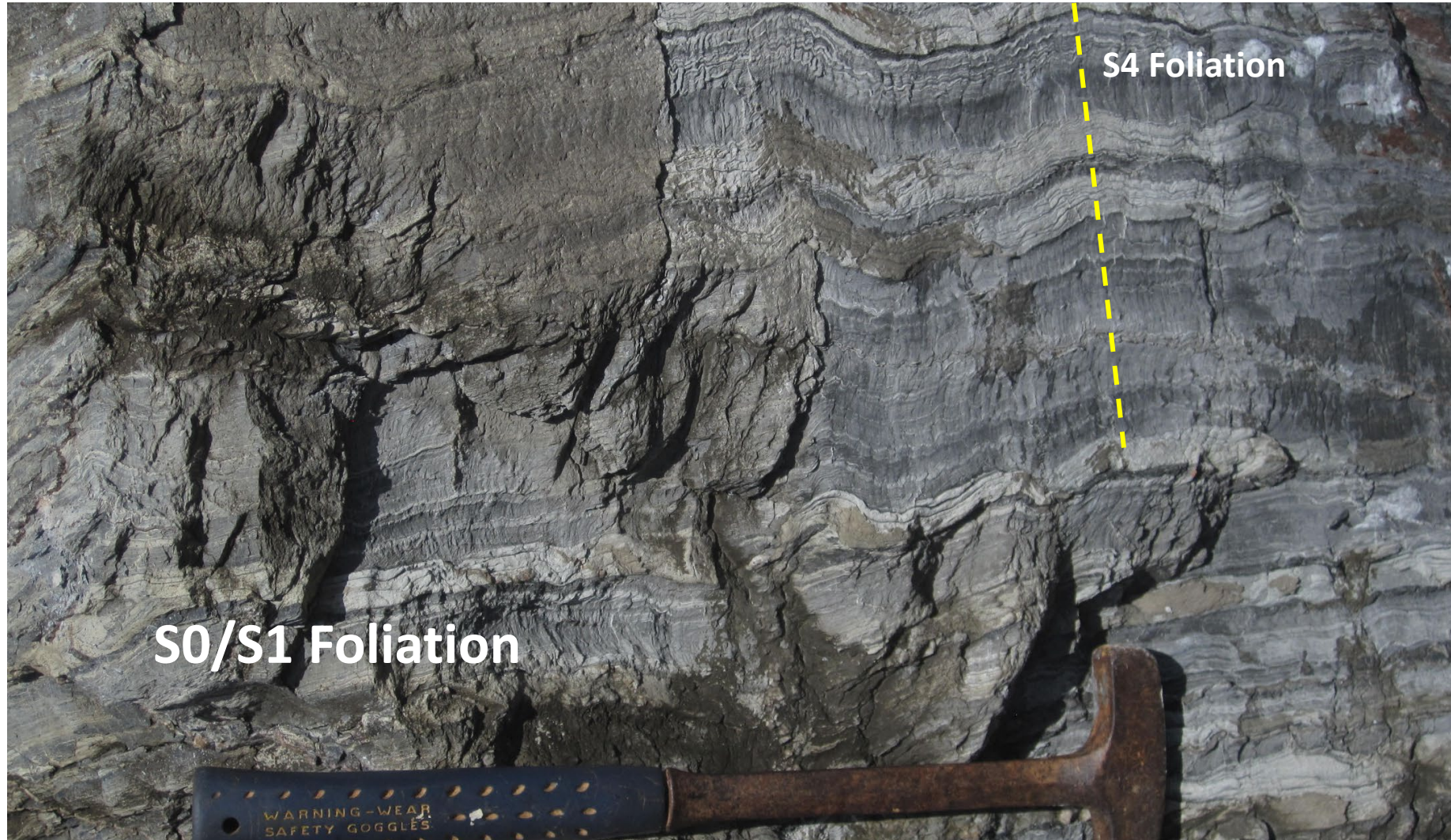
From undeformed mudstones and greywackes bedded sequence.

To a deformed and folded sedimentary sequence registering all the various deformational fabrics from syn-D1 to syn-D5

To a graphitic shear zone characterized by boudinaged veins and a shear fabric overprinting all syn-sedimentary features.



Sedimentary Graphitic Hosted Shear Zones - Foliations



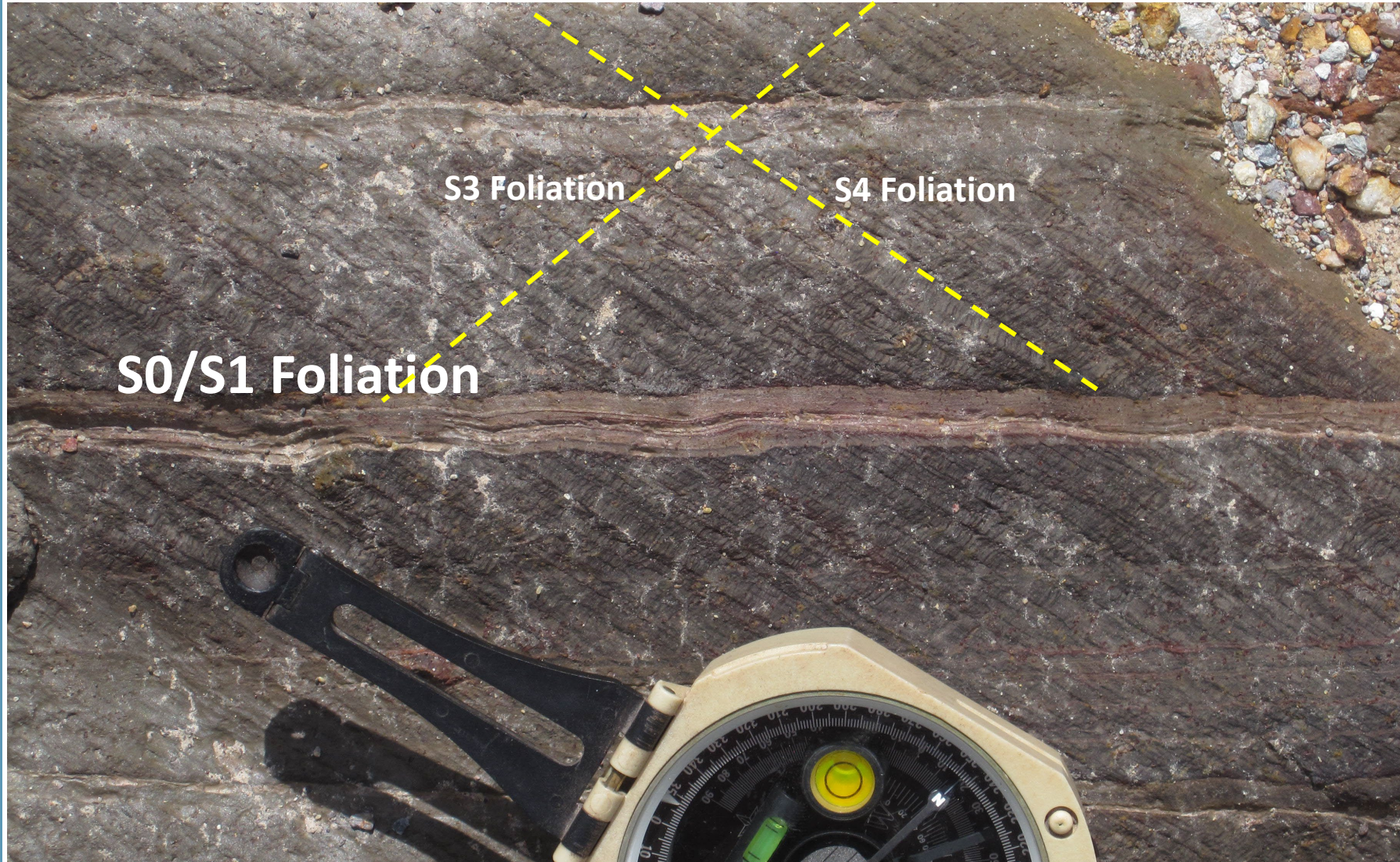
Foliations

Various foliations being developed in the Kumasi sedimentary basin in the hanging wall of the Ashanti Fault.

The bedding has been transposed along the main fabric/foliation S1 during the Eoeburnean thrusting event.

Subsequent fabrics have also formed during strike slip reactivation of the Ashanti Fault, S3 to S5.

Sedimentary Hosted Graphitic Shear Zones - Foliations



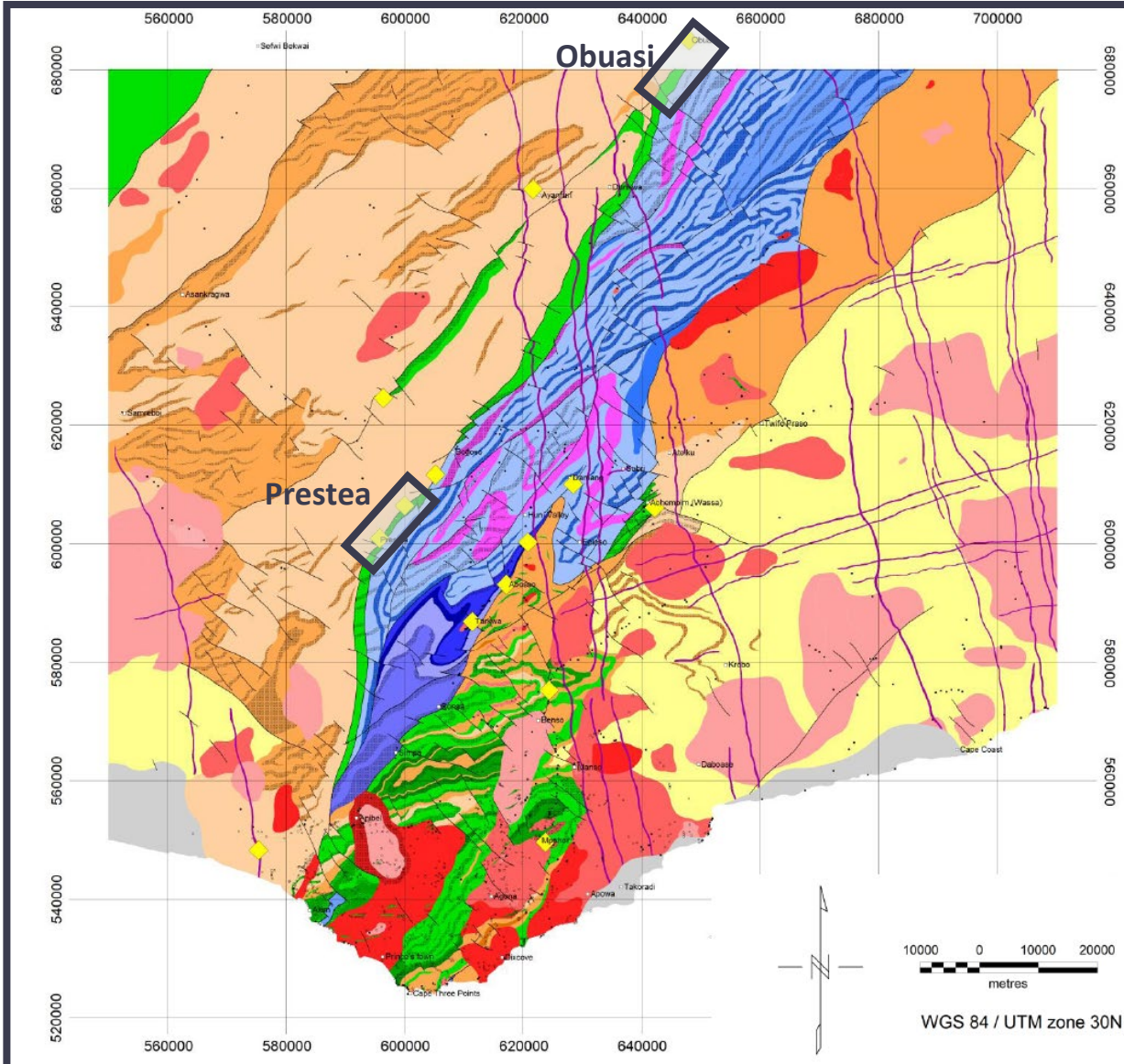
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Fault Fill Quartz Veins



Deposit characteristics

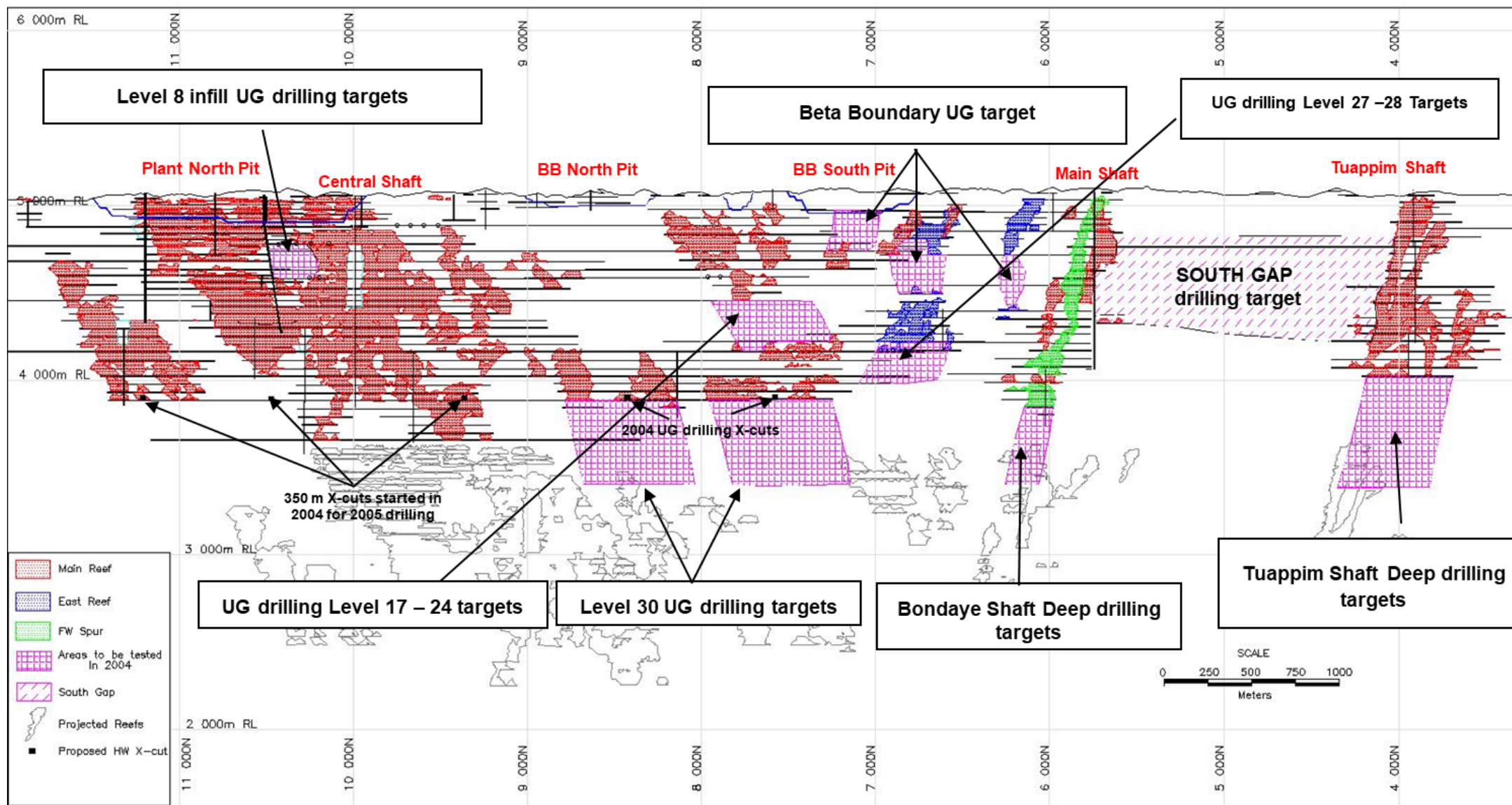
The second type of deposit are Fault Fill Quartz Vein deposits which also occur along the Ashanti trend but are only present at Obuasi and Prestea.

Veins are typically 2m wide but can be up to 10 meters in width. Veins are generally laminated, hosted in multiple graphitic faults refer to as reefs. These are high grade deposits – Typically greater than 10 g/t.

Prestea West Reef structure – Hole UC30-270-S102



Fault Fill Quartz Veins – Prestea Longitudinal



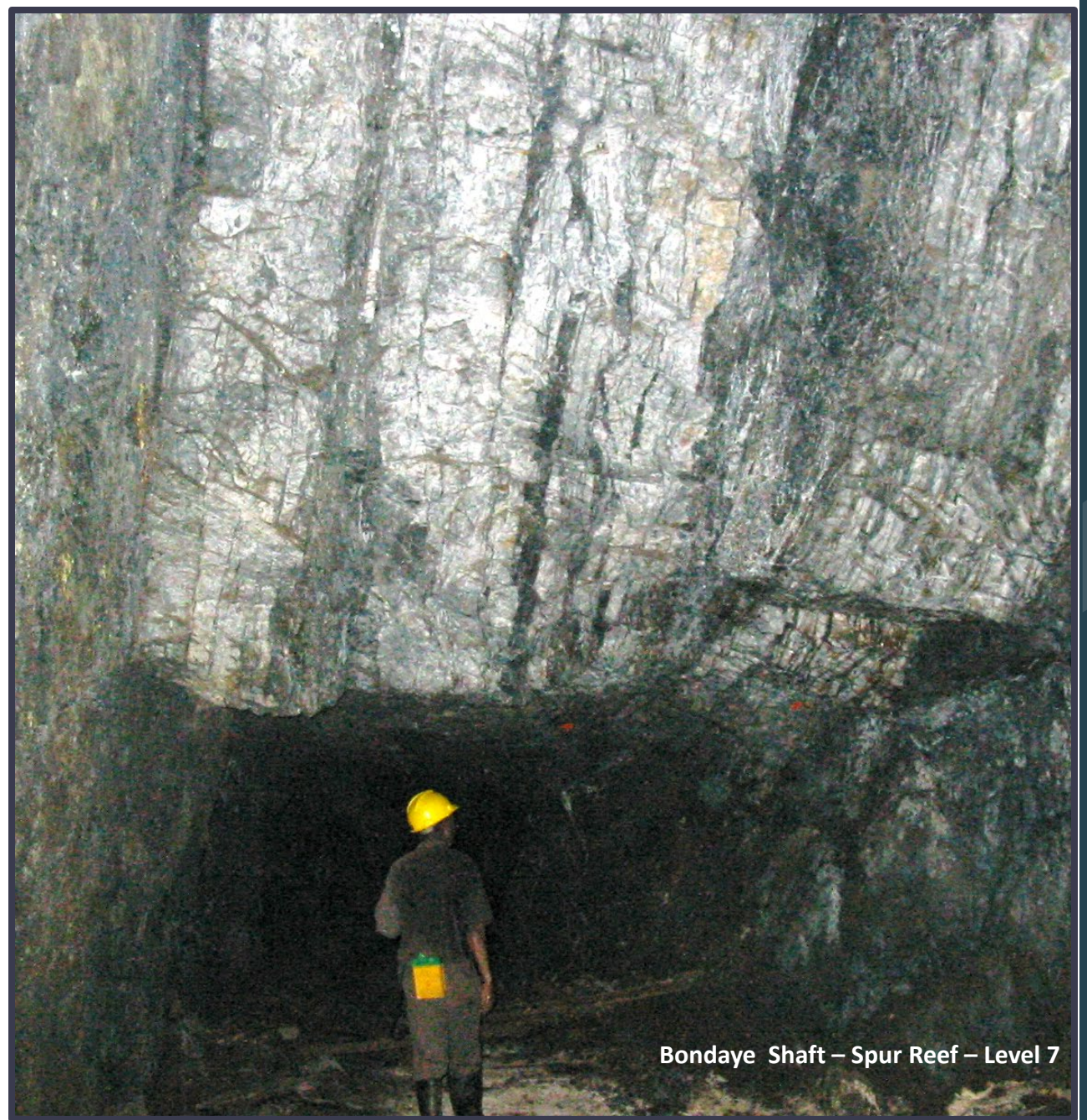
Fault Fill Quartz Veins

Main characteristics of Deposits

Veins are typically 2m wide but can be up to 10 meters in width as seen in this picture of the Spur Reef.

This picture was taken underground at the Bondaye Shaft located towards the South of the 10km trend Prestea mine at level 7.

Veins are generally laminated hosted in multiple graphitic faults refer to as reefs. These are high grade deposits – Typically greater than 10 g/t.



Bondaye Shaft – Spur Reef – Level 7

Fault Fill Quartz Veins

The picture on the right of the Main Reef was taken underground at the Central Shaft and is a good representation of the laminated quartz veins developed along graphitic faults.

The picture below comes from a drilling program on the West Reef and is also a good representation of the laminated Quartz Veins with sulphides occurring along laminations.

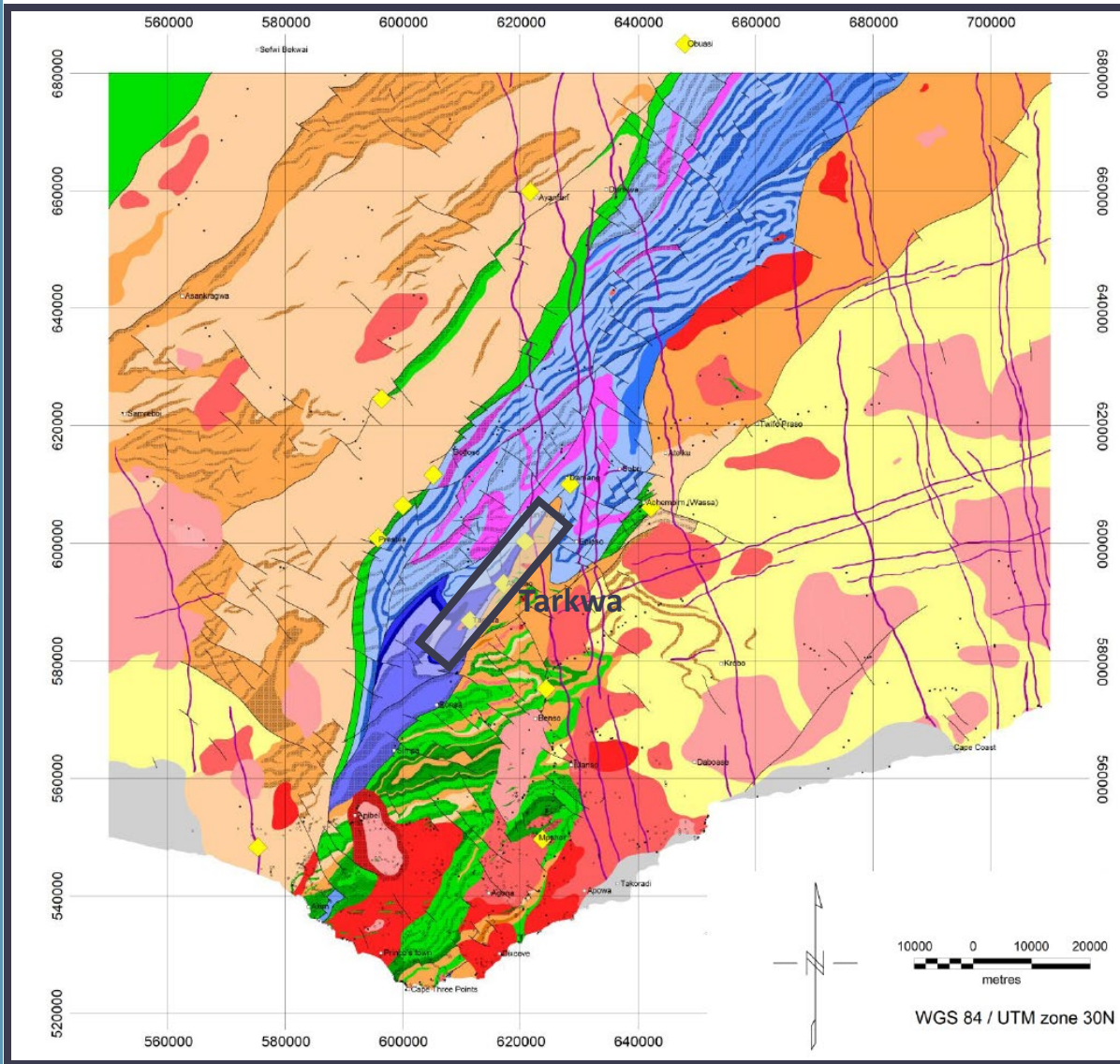


West Reef – Hole UC1044

Main Reef – Level 17 – XC207



Paleoplacer



Deposit Characteristics

The third type of deposit found in the Southern Ashanti belt are Paleoplacers which occur on the South-Eastern margin of the large-scale fold within the Tarkwaian.

These deposits are characterized by sedimentary hosted mineralization hosted along narrow Banket conglomerate horizons intercalated with sandstone units characterized by iron oxides cross beddings.

This type of deposit has only been discovered in the Ashanti Belt with no other paleoplacer deposits in West-Africa.

These deposits are characterized by lower-grade mineralization with gold grade averaging less than 2 g/t.

Tarkwa-Teberebie-Iduaprim.

Paleoplacer



Pepe T1 Conglomerate – 2004 SEG Visit.



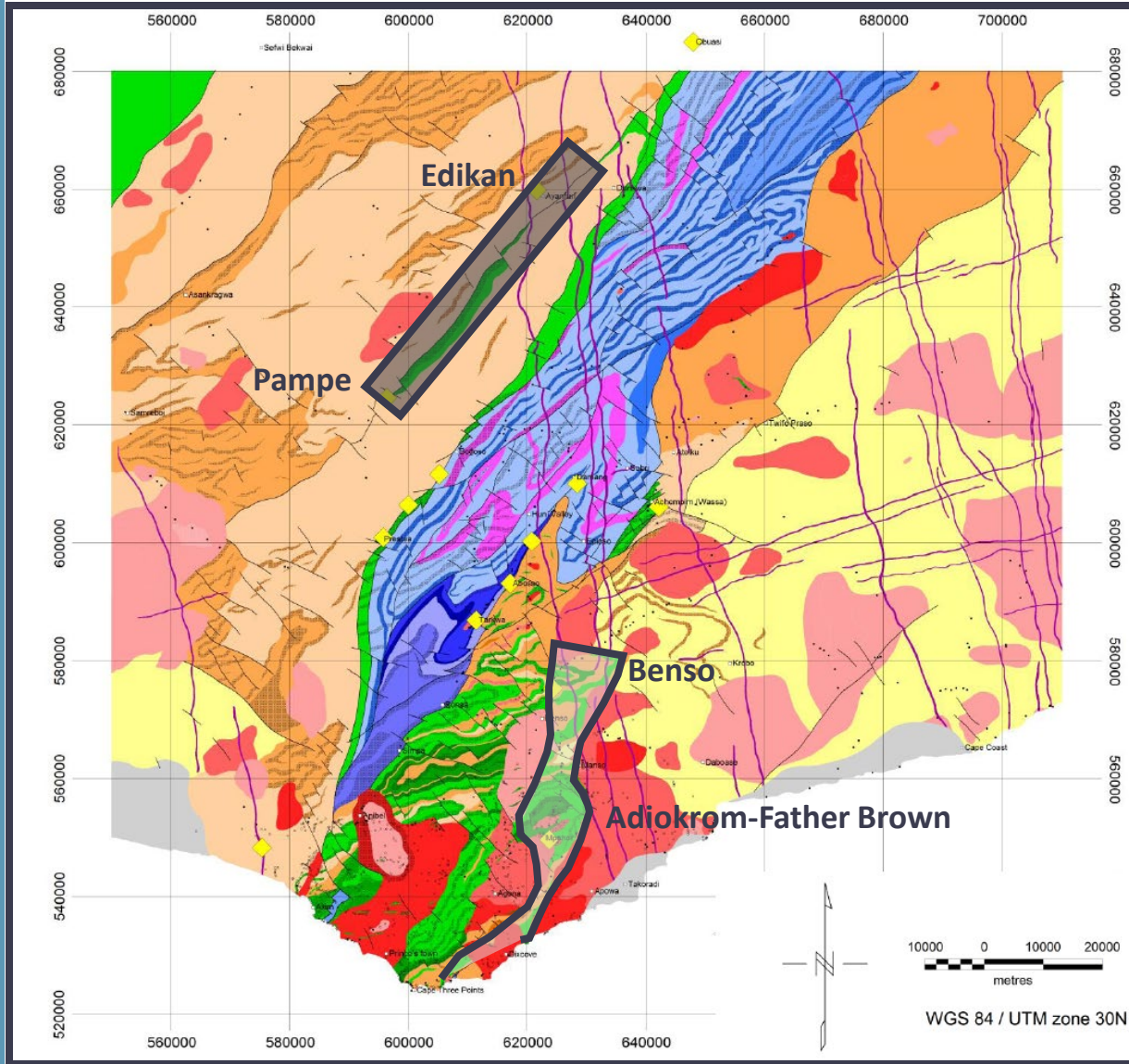
Akontansi T3 Cross Bedding – 2004 SEG Visit.

Main characteristics of Deposits

The picture on the left is the typical conglomerate horizons of the Banket formation.

The picture on the top is a mineralized horizons of micro-conglomerates characterized by heavy minerals cross-beddings.

Intrusive Hosted Gold Deposits



Deposit characteristics

The fourth type of deposit found in the Southern Ashanti belt are Intrusive Hosted deposits.

These Intrusive Hosted deposits occur along second order structures such as the Akropong trend in the Kumasi basin and the Manso trend in the Southern portion of the Ashanti belt and are characterized by a penetrative fabric and can be hosted in both mafic or felsic intrusives.

Mineralization is structurally controlled and generally occur along well defined discrete shear zones, the most common associated sulphides is pyrite.

Adiokrom-Father Brown-Benso-Edikan.

Intrusive Hosted Gold Deposits



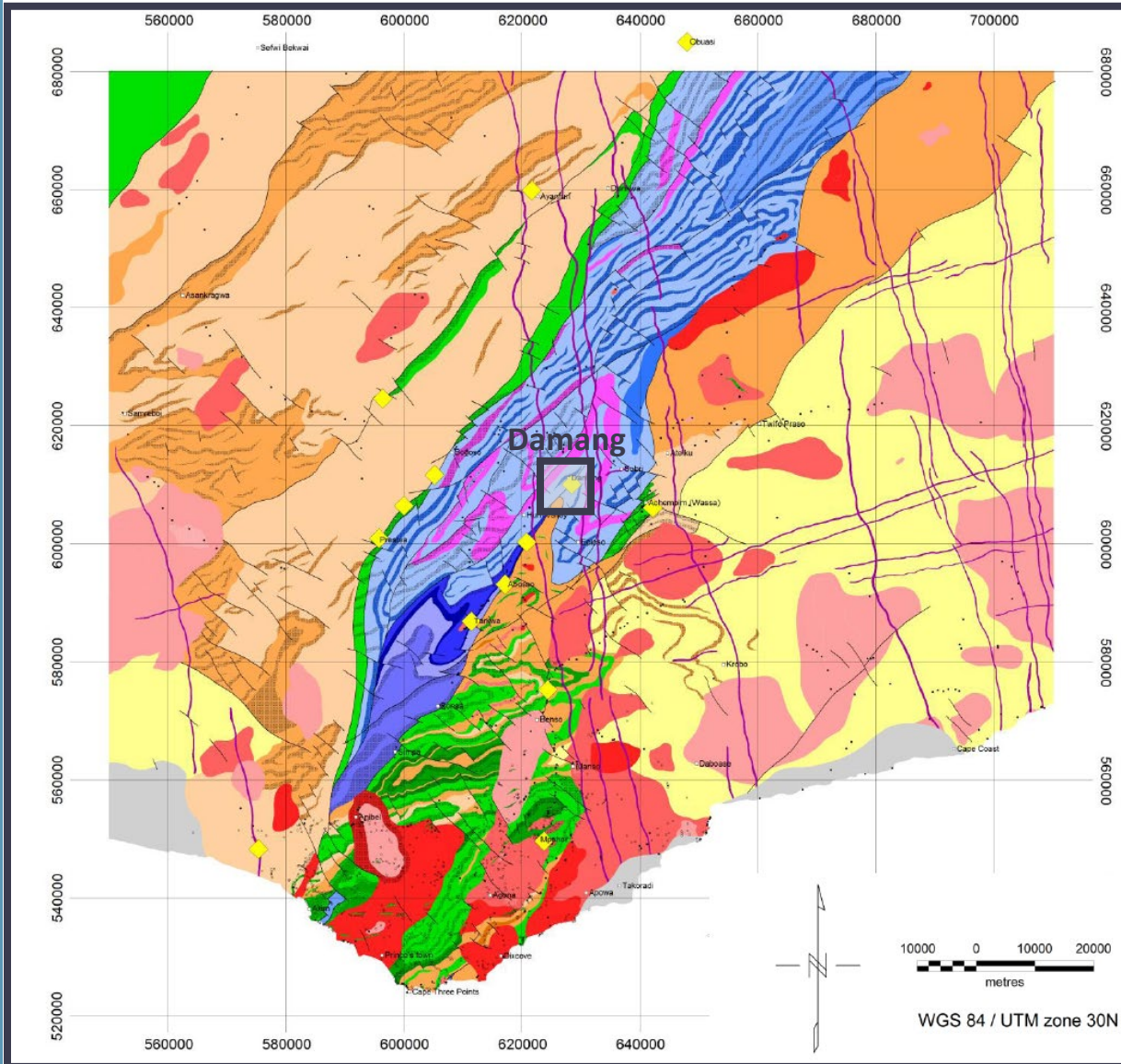
Subriso East – South Wall



The picture on the right is from the Subriso East deposit at Benso, mineralization is associated with a well developed, discrete shear zone with a penetrative fabric developed in the footwall.

The picture on the top is from an undeformed gabbro-diorite which is the common hosts at Benso and Hwini-Butre.

Fault Controlled Extensional Veins



Deposit characteristics

The Damang mine is the only known thrust fault related deposit in the Ashanti belt. The deposit is characterized by low angle, undeformed extensional veins.

The late extensional quartz vein arrays generally form in the footwall of the low angle thrust Faults.

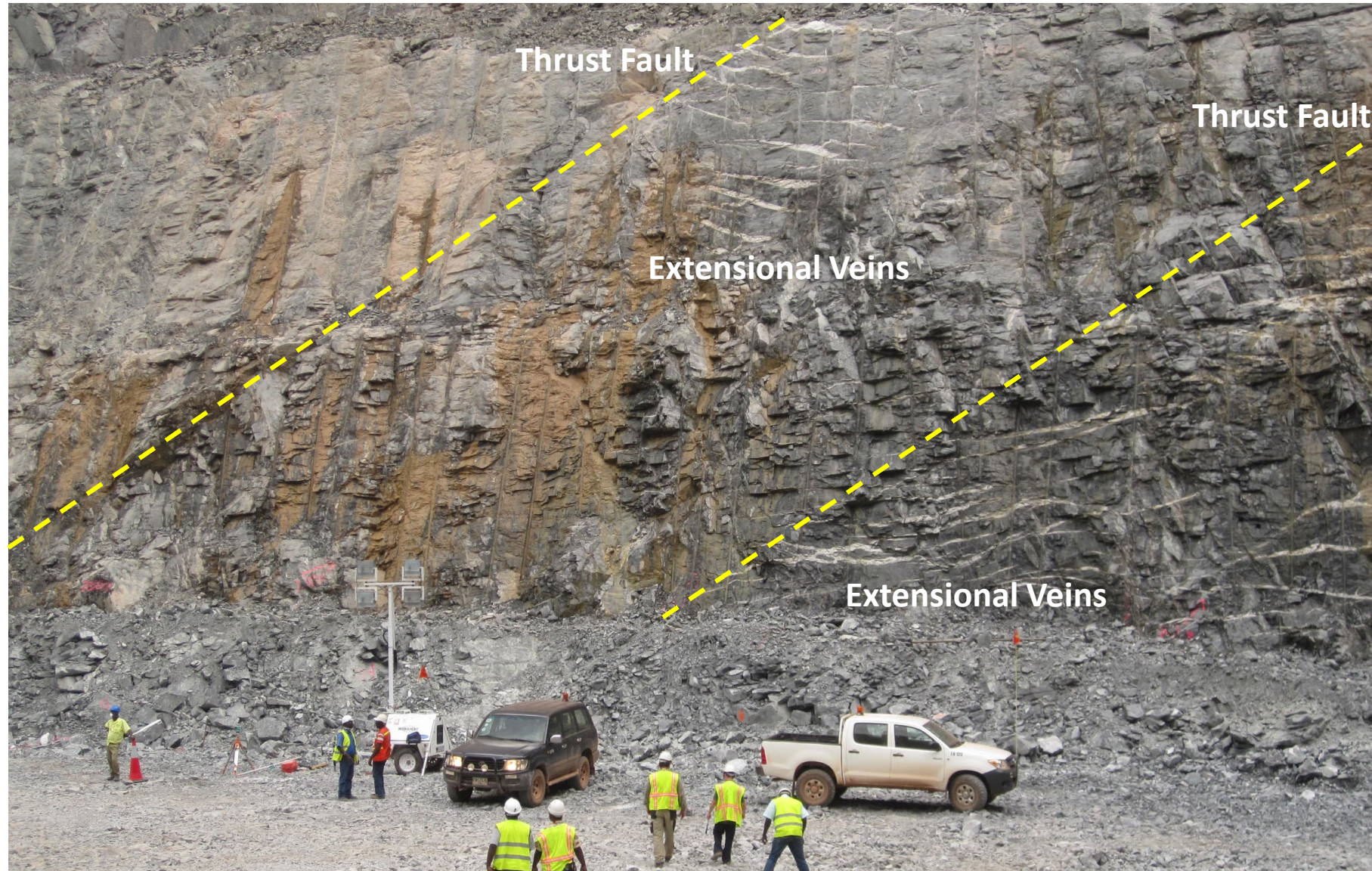
The Mineralization is hosted in Tarkwain sedimentary sequences and younger felsic dykes.

Pigois et al., 2003, characterized the deposit as sub-horizontal en-echelon veins associated with post peak metamorphism fluids.

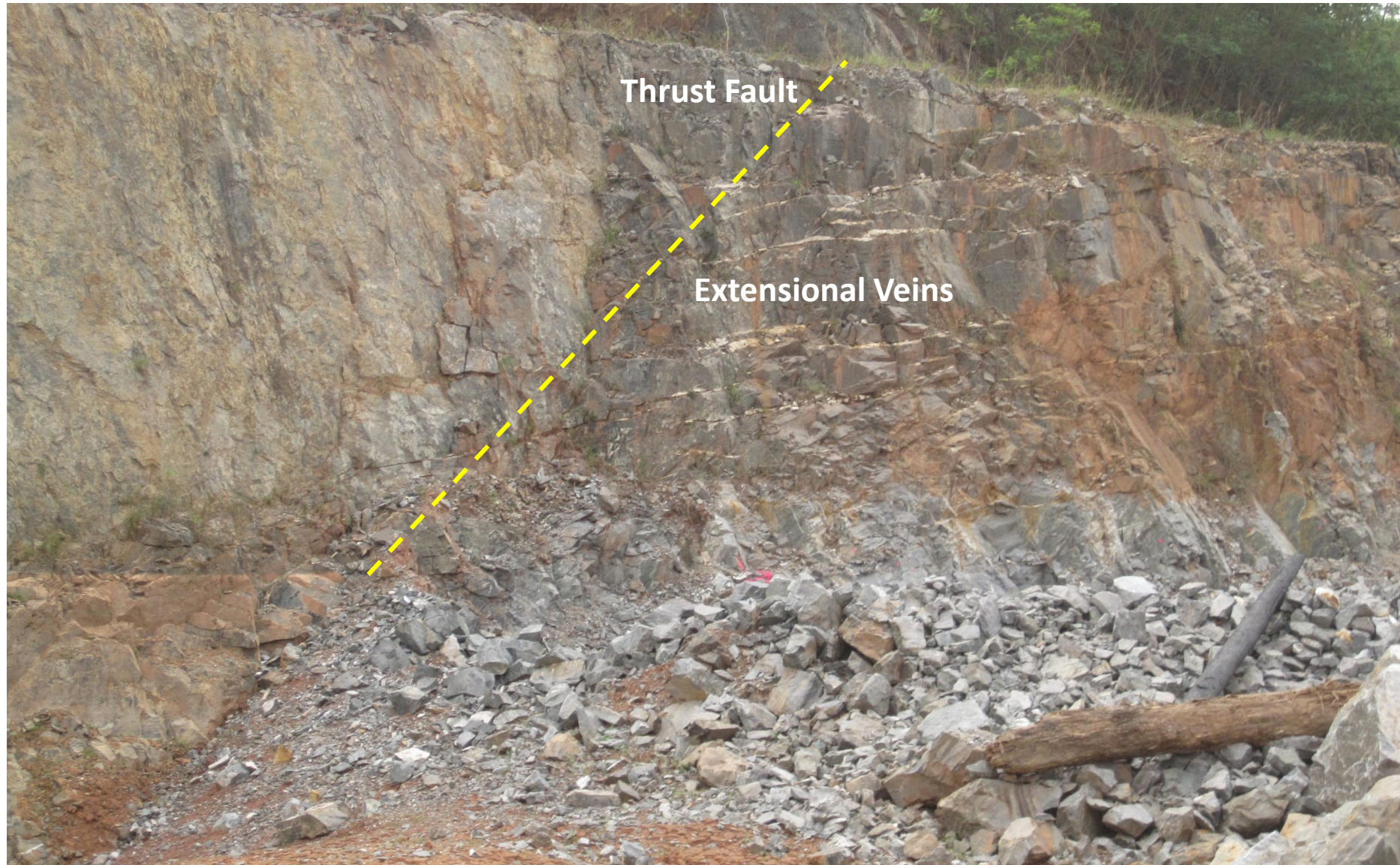
No other similar deposits in the South Ashanti Belt, it's the only deposit in the belt with brittle controls occurring after multiple ductile deformational events.

Low Grade bulk deposits – Typically lower grade than 1.5 g/t.

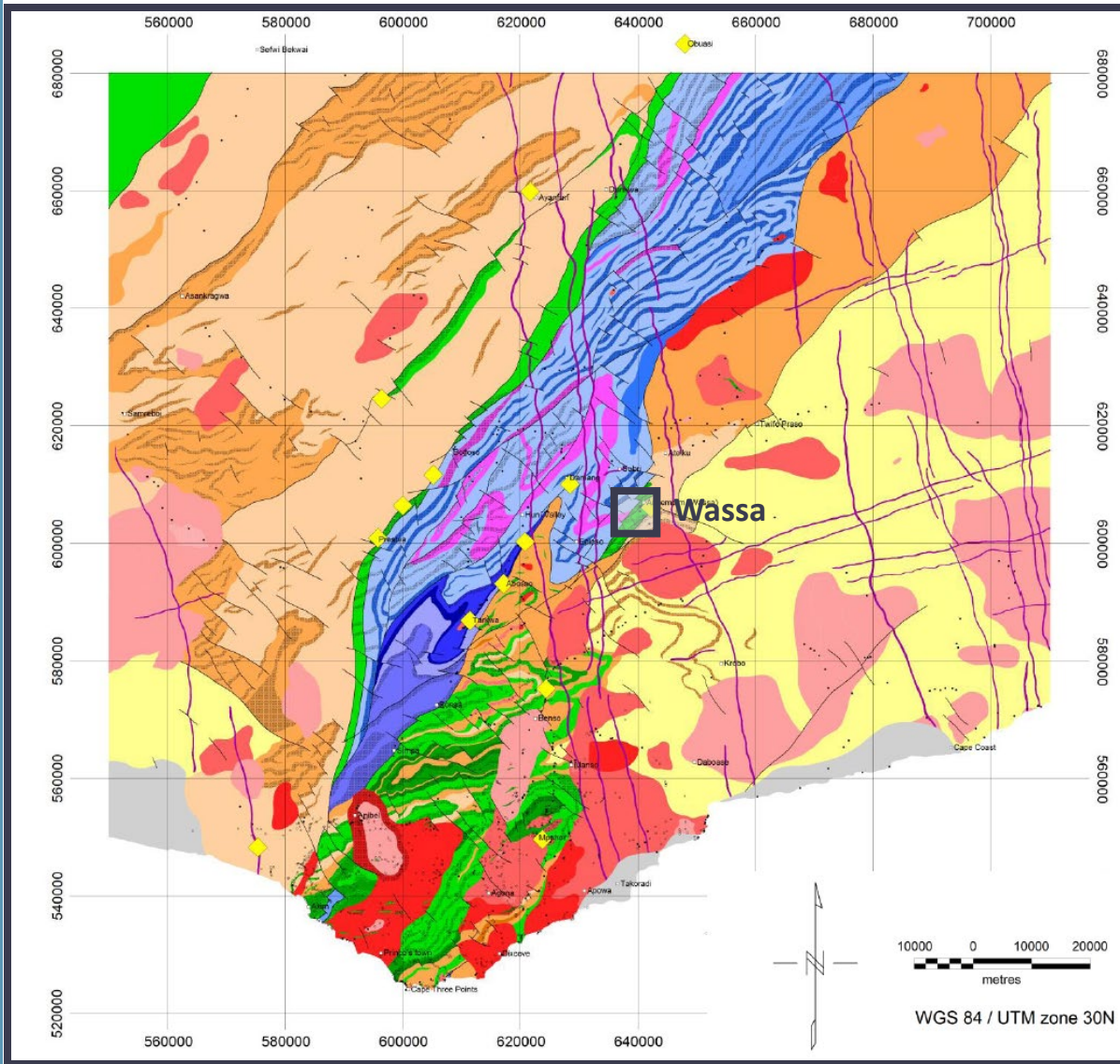
Fault Controlled Extensional Veins



Fault Controlled Extensional Veins



Folded Quartz Veins System



Main characteristics of Deposit

The last type of deposit found in the Southern Ashanti belt are Folded Quartz Veins systems, only one such deposit is known in the belt, the Wassa mine.

The mineralized hydrothermal event at Wassa is affected by all deformational phases of the Eburnean orogeny, making the veins syn-Eoeburnean. The quartz veins are transposed along the main foliation, resulting in boudinaged and folded veins.

The Wassa mine is located only 20km to the East of the Damang deposit. The juxtaposition of this multi-phase, folded vein deposit in contrast to the undeformed, brittle extensional veins style of deposit is striking.

With the sedimentation of the Tarkwaian basin dated at **2133Ma** by Pigeois and the Wassa Porphyry age of **2191Ma** obtained by Parra-Avila et al., as well as direct dating on Pyrite grains by Le Mignot et al., giving an age of **2164Ma**, the Wassa deposit could potentially be a gold source for the Tarkwa Paleoplacer deposits.

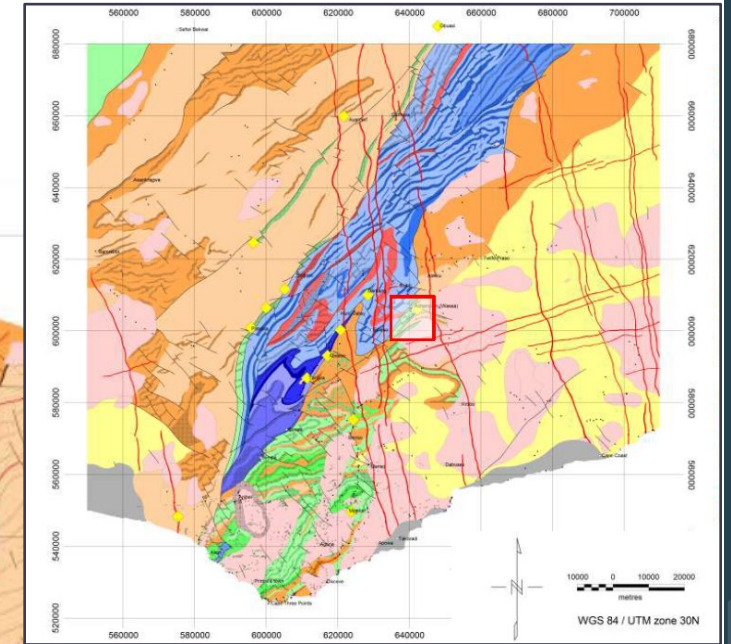
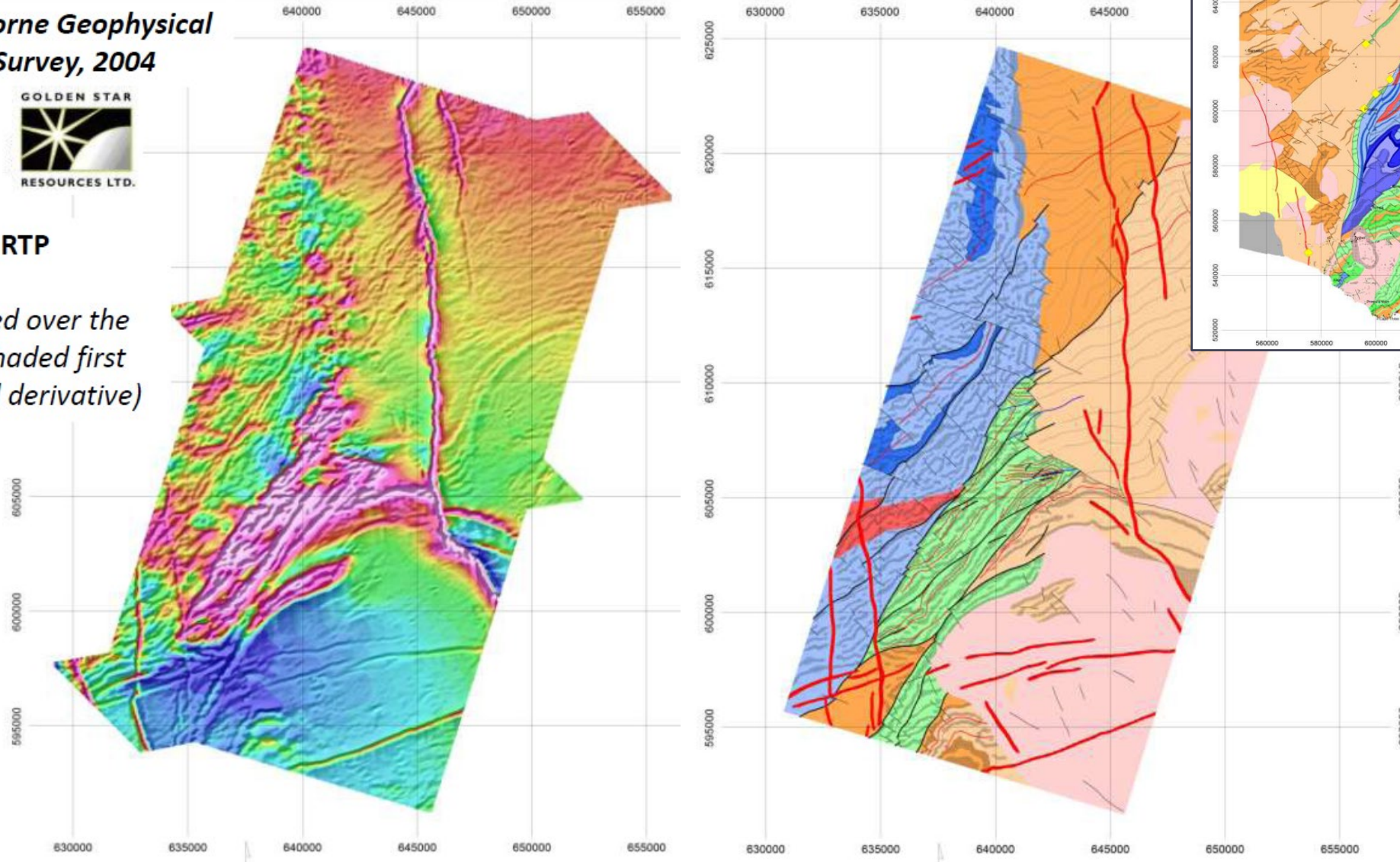
Folded Quartz Veins System

Airborne Geophysical
Survey, 2004



RTP

(draped over the
sun-shaded first
vertical derivative)



Perrouy et
al. 2012

Folded Quartz Veins System – Structural Settings

Wassa Deposit Structural Settings

The stratigraphy underlying the Wassa Mine is composed of mafic volcanic flows with minor intercalated sedimentary horizons of mudstones, iron formation and greywacke, the sequence is locally intruded by dioritic dykes (purple) and a felsic Porphyry (blue).

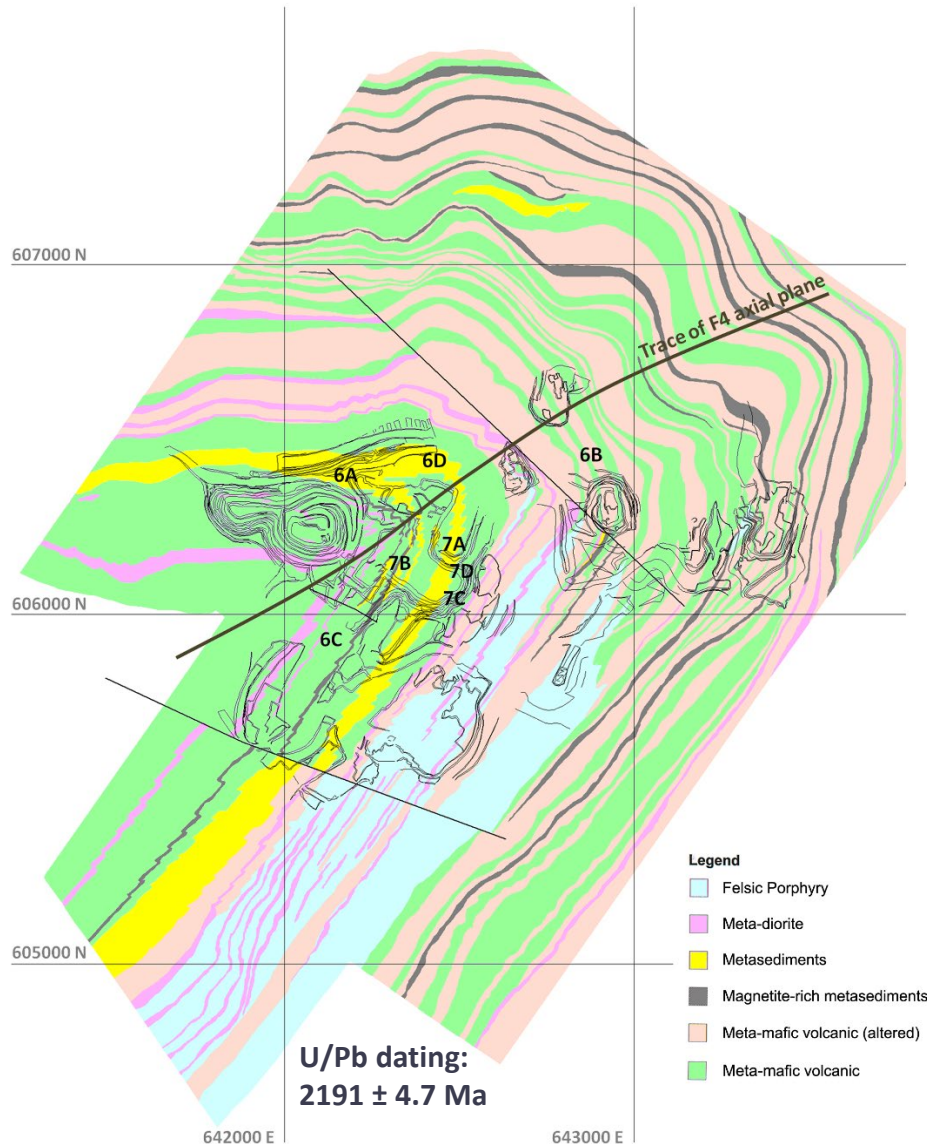
D1: N-S Shortening – Early Gold bearing synD1 quartz veins and a penetrative foliation sub-parallel to transposed lithological contacts.

D2: Extension period – No local deformation.

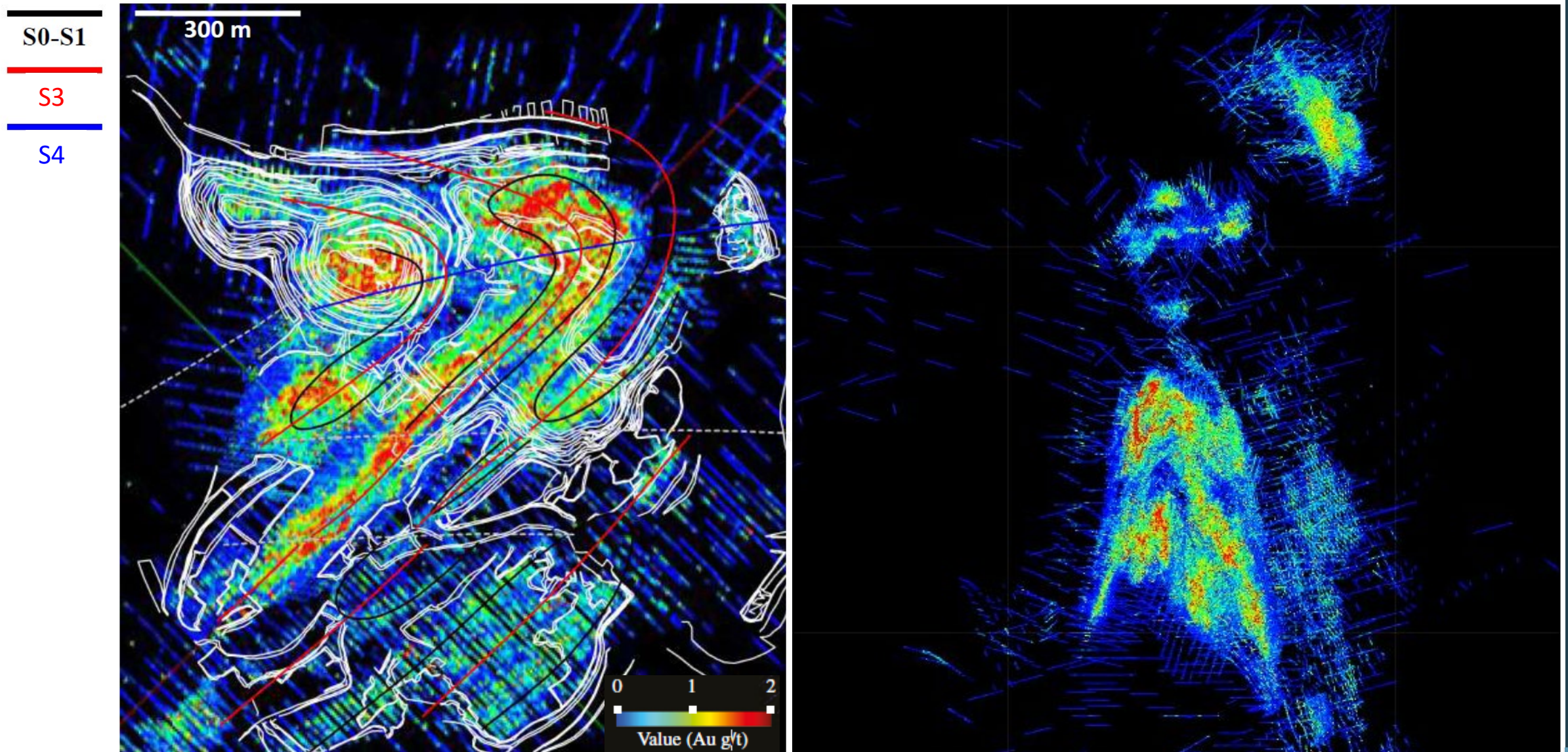
D3: NW-SE Shortening – Penetrative second foliation at Wassa and tight isoclinal folds.

D4: NNW-SSE Shortening – Severely buckled the Wassa stratigraphic sequence underlying the Wassa property, regional scale, steeply dipping, tight fold patterns (F4 Fold) and a third penetrative foliation (S4).

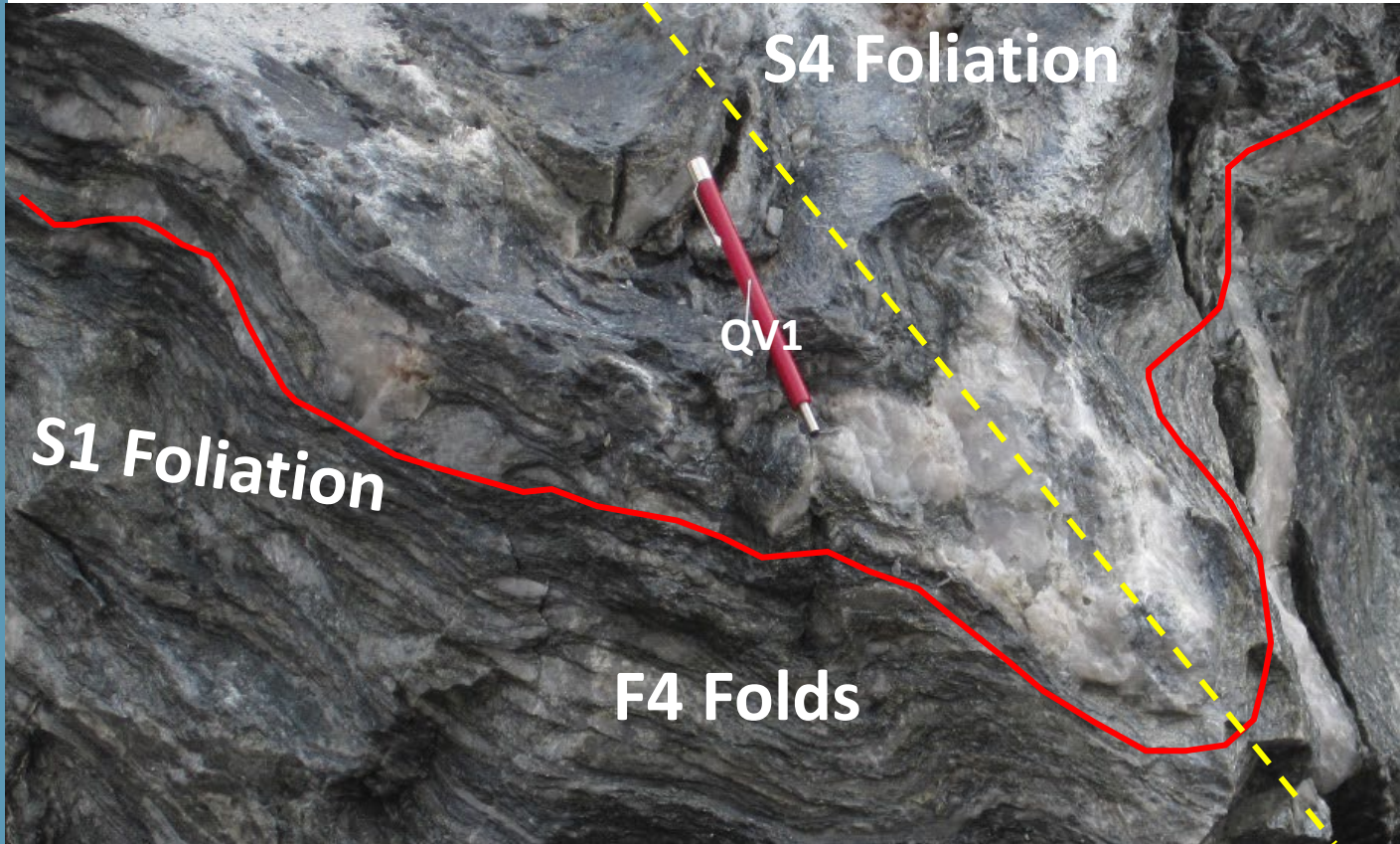
D5: Horizontal Compressional event – Open recumbent folds and associated sub-horizontal foliation/crenulation.



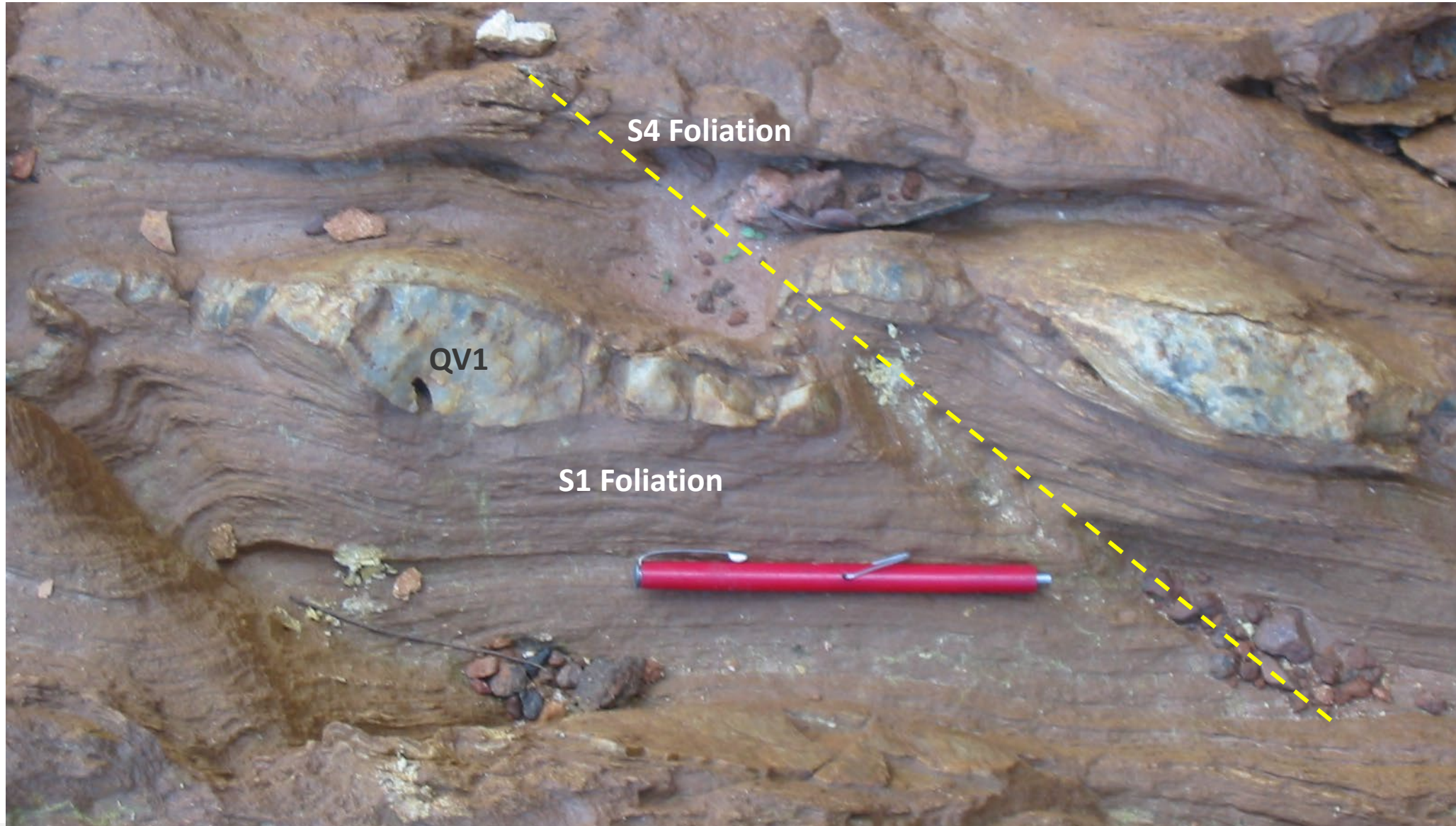
Folded Quartz Veins System– Drill Data 3D Model



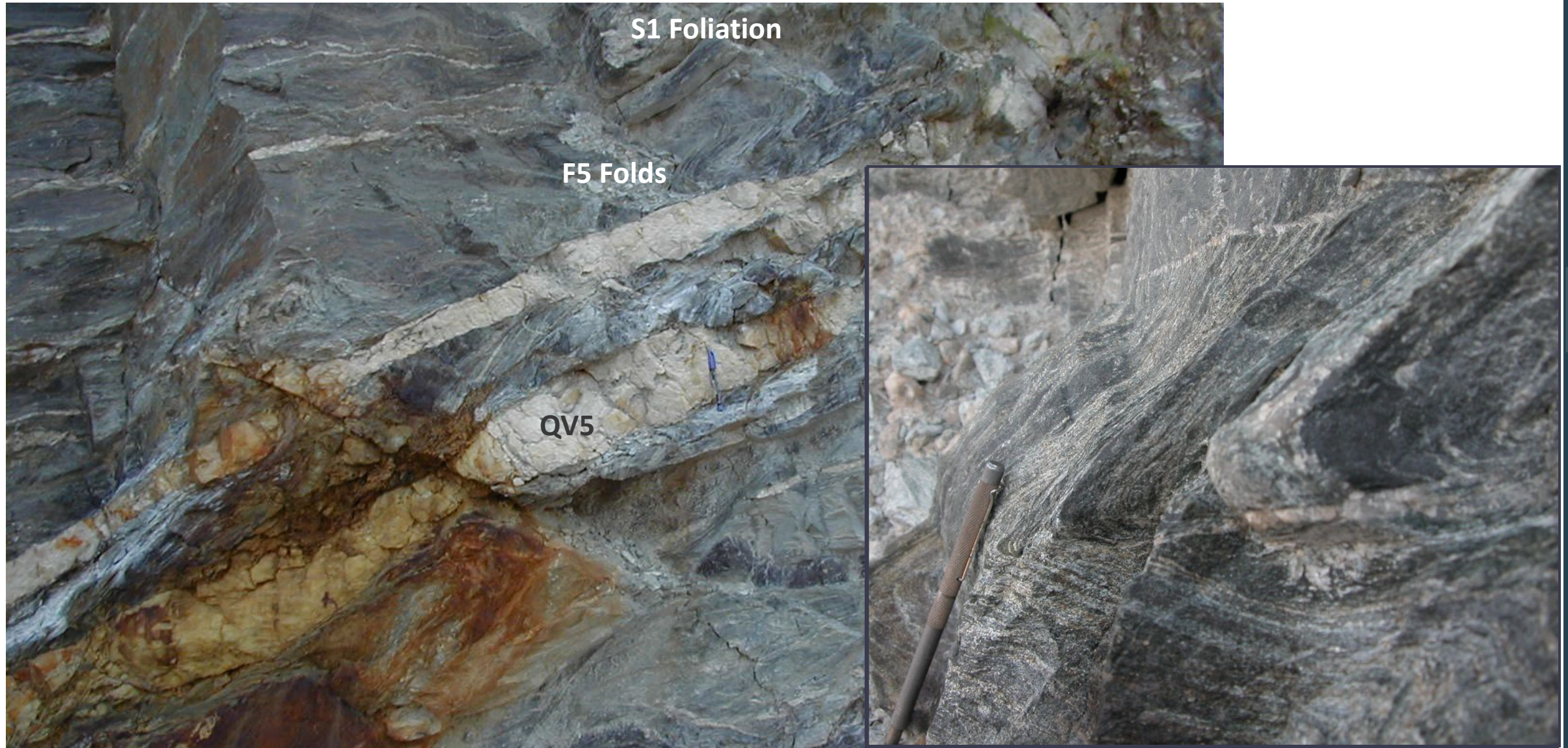
Folded Quartz Veins System– Pit Walls Folded Veins



Folded Quartz Veins System – Pit Floor Folded Veins

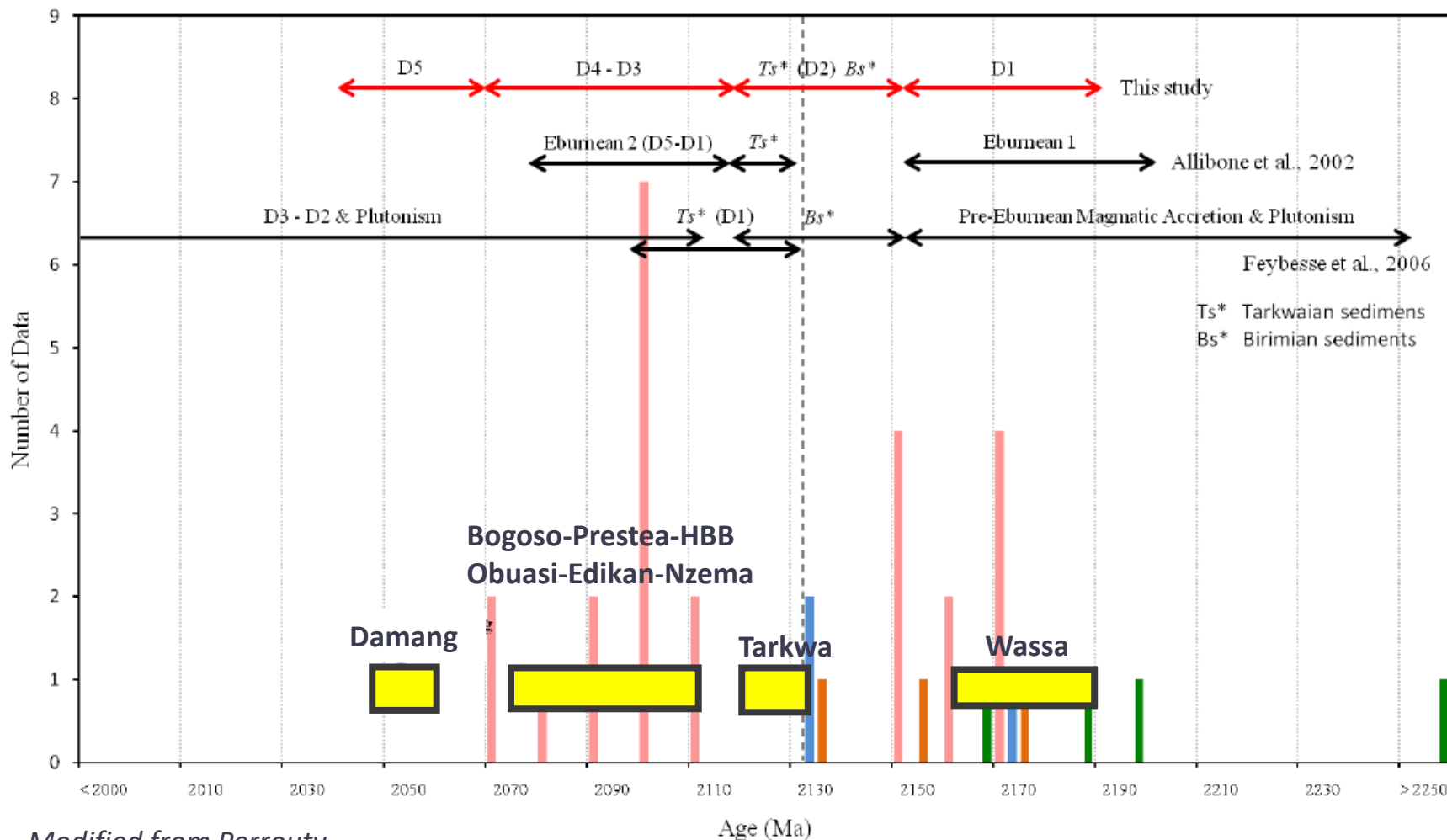


Folded Quartz Veins System– Pit Walls Folded Veins



Gold Deposits Timing – South Ashanti Belt

Dating in SW Ghana (U/Pb and Pb/Pb $< \pm 10$ Ma)



Modified from Perrouty
et al. 2012

Dating Compilation Ashanti

The top of the slide shows the deformational history of the Ashanti belt as described by Perrouty, Allibone and Feybesse.

The bottom of the slide shows the pink bars are dating for granites which fall into two clusters, one of Eoeburnean age and a second cluster of Eburnean age.

When grouping these deposits by timing instead of litho-structural types, Wassa is the only known deposit of Eoeburnean timing, while the Paleoplacer deposits are syn-D2 corresponding to the extension phase between the Eoeburnean and Eburnean orogeny, while all other deposits are syn-Eburnean with Damang being the only syn-D5 deposit.



Geology and Structural Settings of the Southern Oumé-Fettèkro Belt

Regional Geology – The Oumé-Fettèkro Belt

Geology of the Oumé-Fettèkro Belt

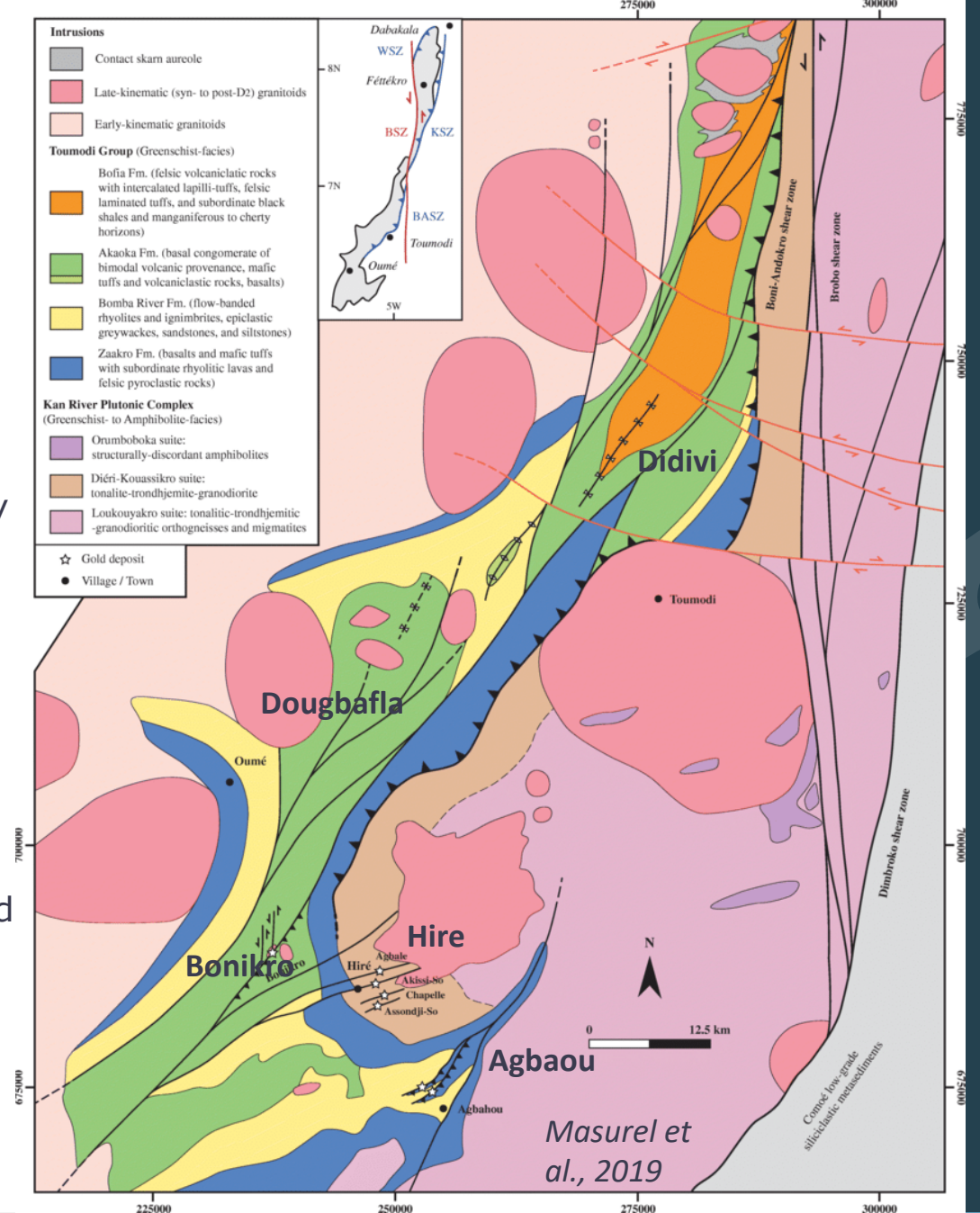
This geology map is from Masurel et al., 2019 which was published from work conducted during the West African Research Initiative (WAXI) phase 3.

The South of the belt is mostly composed of the volcano-sedimentary sequences from the Zaakro, Bomba River and Akaoka formations, while the central part of the belt is dominated by the felsic volcanic flows and associated volcanoclastics of the Bofia formation.

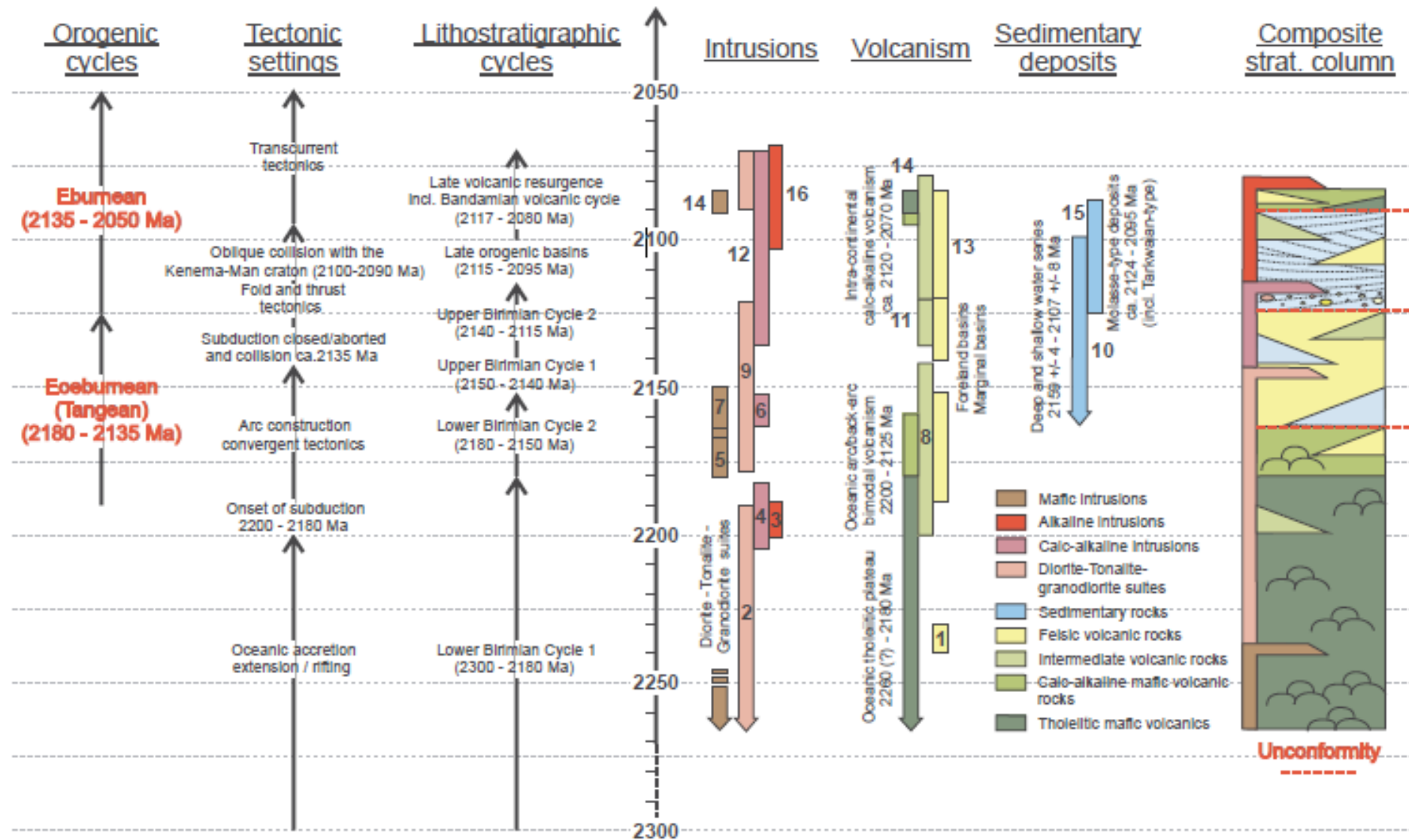
The Bonikro, Dougbafla and Didievi deposits are all hosted in the basaltic flows of the Akaoka formation but associated with younger porphyritic intrusives.

The Hire deposits which consists of Akissi-so, Assondji-so, Chapel and Agbale zones are hosted in the Diéri-Kouassikro tonalite-trondhjemitic-granodiorite suite.

The Agbaou deposits are hosted in the volcano-sedimentary sequence of the Zaakro formation.



Structural Settings of The Oumé-Fettèkro Belt

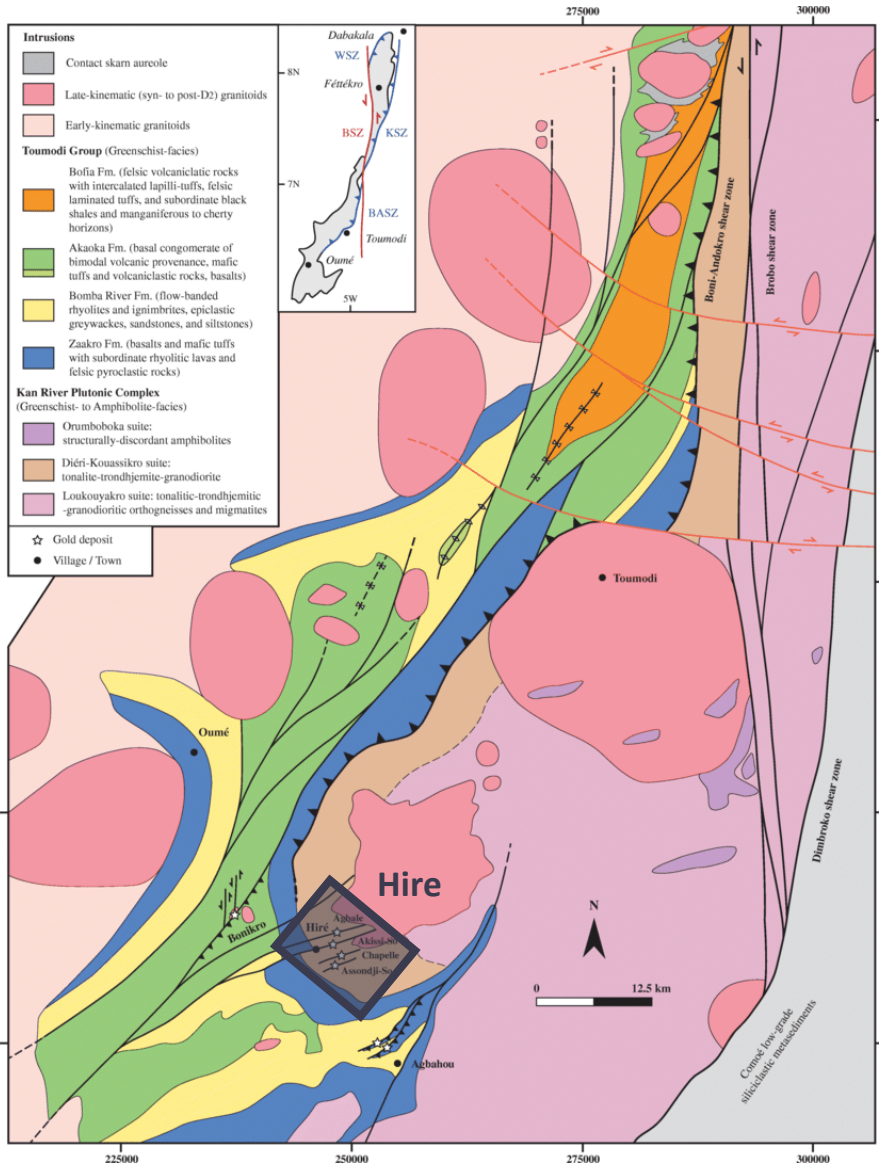


Meriaud et al.
2020



Deposit Types of the Southern Oumé-Fettèkro Belt Based on Litho- Structural Contexts

Intrusive Hosted Gold Deposits



Deposit characteristics

The first type of deposit found in the Southern Oumé-Fettékro belt are Intrusive Hosted deposits.

These Intrusive Hosted deposits occur along minor structures and are characterized by a penetrative fabric and are hosted in the tonalite-Trondhjemite-Granodiorite of the Dieri-Kouassikro suite.

Mineralization is structurally controlled and generally occur along well defined discrete shear zones, the most common associated sulphides is pyrite.

The most known deposit are found on the Hire mine and consists of multiple structures hosted in tonalitic and granodioritic intrusive bodies.

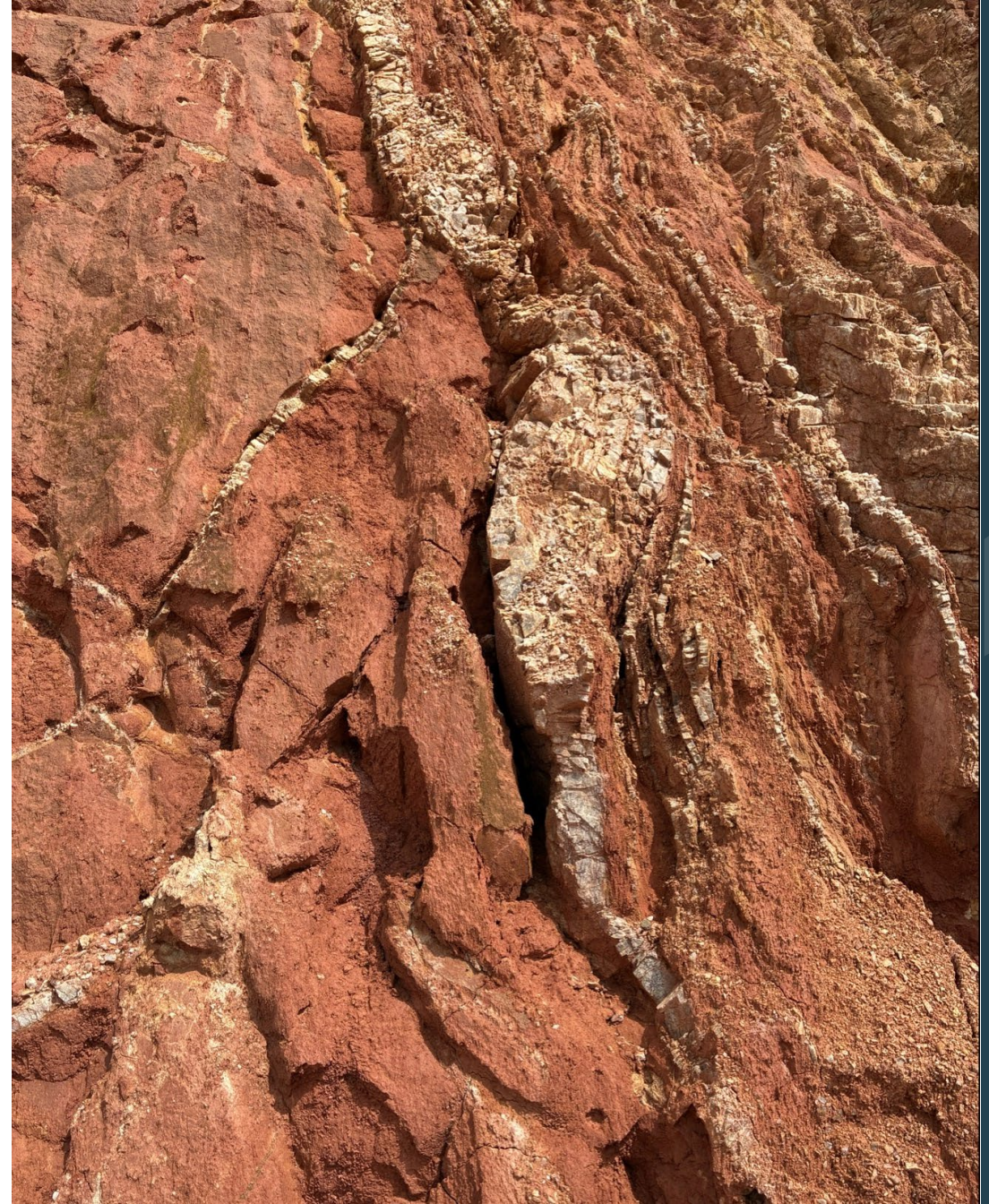
Akissi-so, Assondji-so, Chapel and Agbale.

Intrusive Hosted Gold Deposits

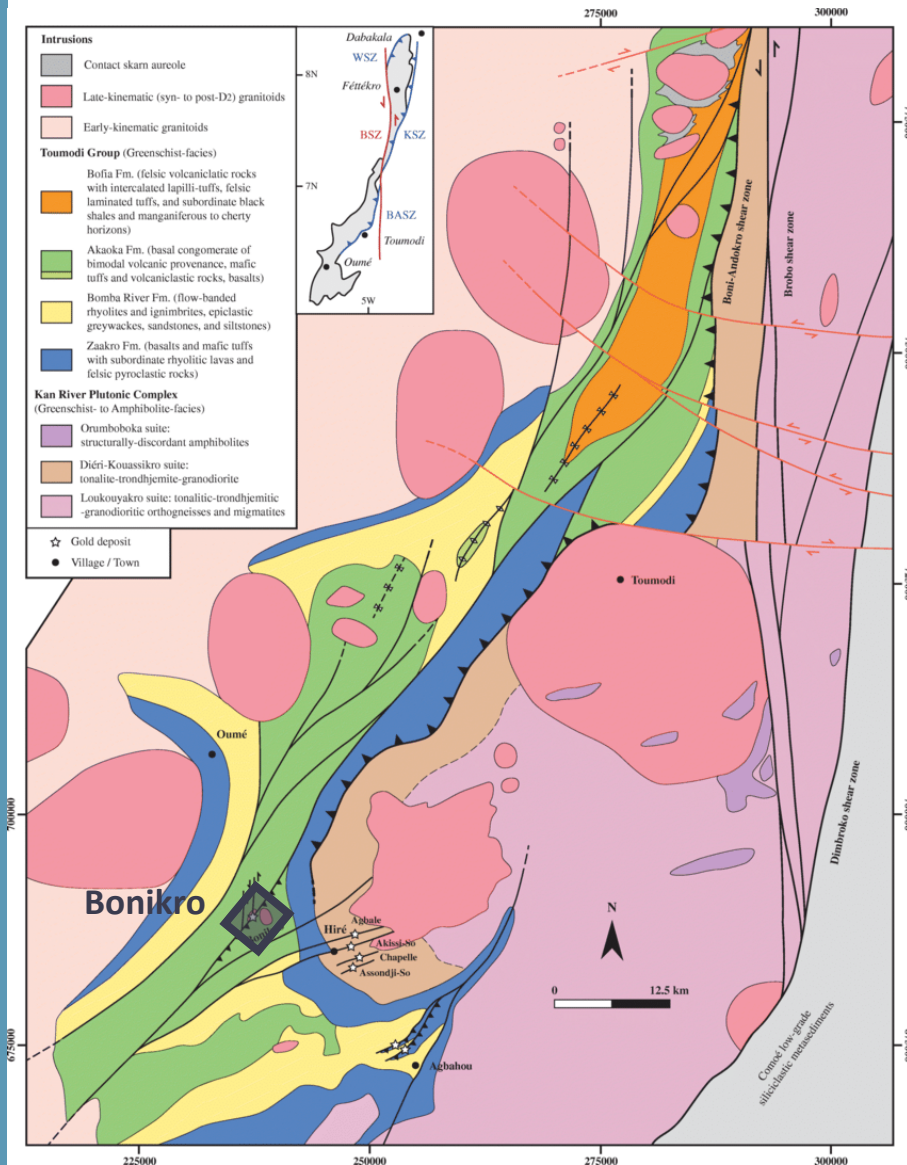


The picture on the right is from the Hire Chapel pit West Wall exposing discrete shear veins zone with a penetrative fabric developed in the shear zone and extensional veins in the footwall.

The picture on the top is from the Hire granodiorite host affected by a penetrative fabric at the contact with the shear zones.



Intrusive Related Gold Deposits (IRGD)



Deposit characteristics

The second type of deposit found in the Southern Oumé-Fettékro belt are Intrusive Related Gold deposits.

This Intrusive Related Gold deposit is hosted in a porphyritic granite along minor North-South structures without any major structures appearing on the regional magnetic survey.

Mineralization is controlled by the emplacement of Magmatic fluids which occur as sheeted veins and are characterized by a metal suite of Tungsten, Bismuth, Molybdenum and tellurium.

The only known Intrusive Related Gold deposit in West-Africa is the Bonikro deposit which makes it somewhat of an anomaly.

Other known IRGD's in the world include Vasilkovka and Berezovky in Kazakhstan and Russia on the Asian continent, and Donlin Creek, Fort Knox, Pogo and Dublin Gulch in Alaska and the Yukon on the North-American continent.

Bonikro

Intrusive Related Gold Deposits

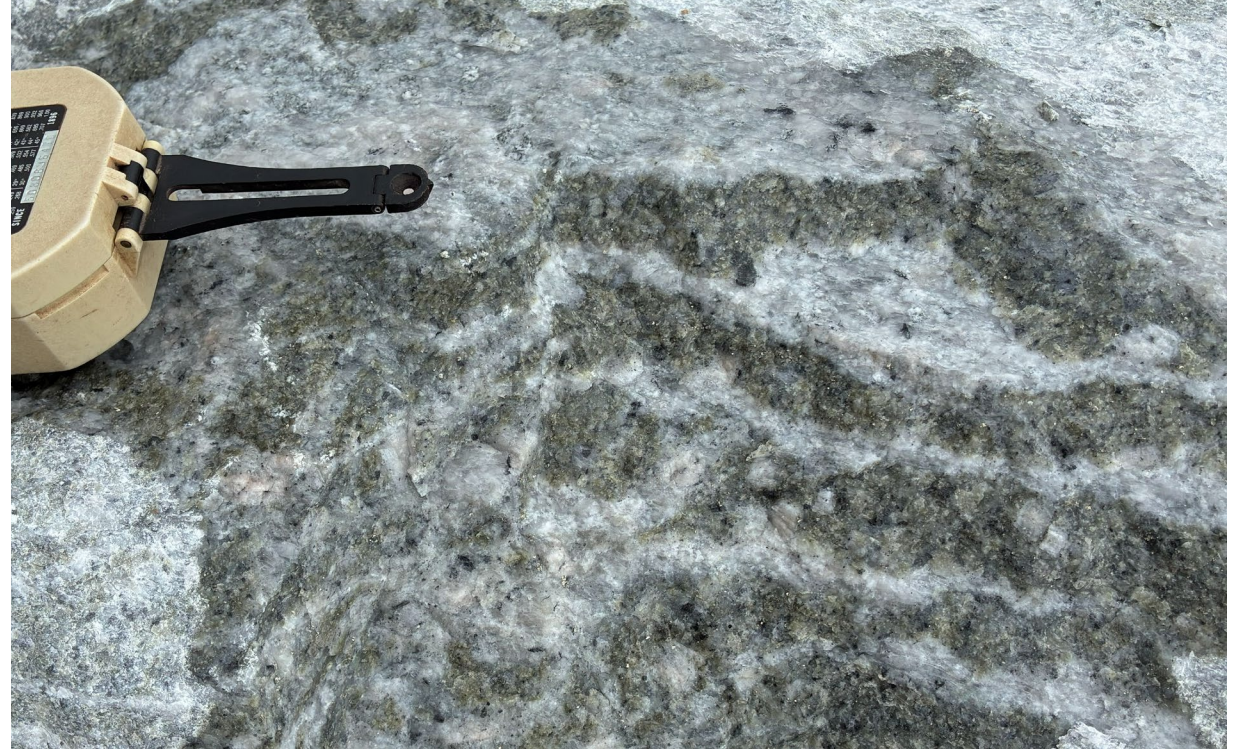
Two mineralization styles have been observed in the Bonikro pit:

- Intrusive related gold bearing veins which occur as Au-W-Mo sheeted veins hosted in the porphyritic felsic intrusives, this style of mineralization is most predominant in the south portion of the pit where operations are currently doing a push back.
- Orogenic gold mineralization associated with moderately West dipping brittle faults/veins which overprints the intrusive related gold bearing veins. The gold mineralization is associated with molybdenite rich veins and faults.



North-East corner of the Bonikro pit exposing several late brittle mineralized faults characterized with fault-filled quartz veins.

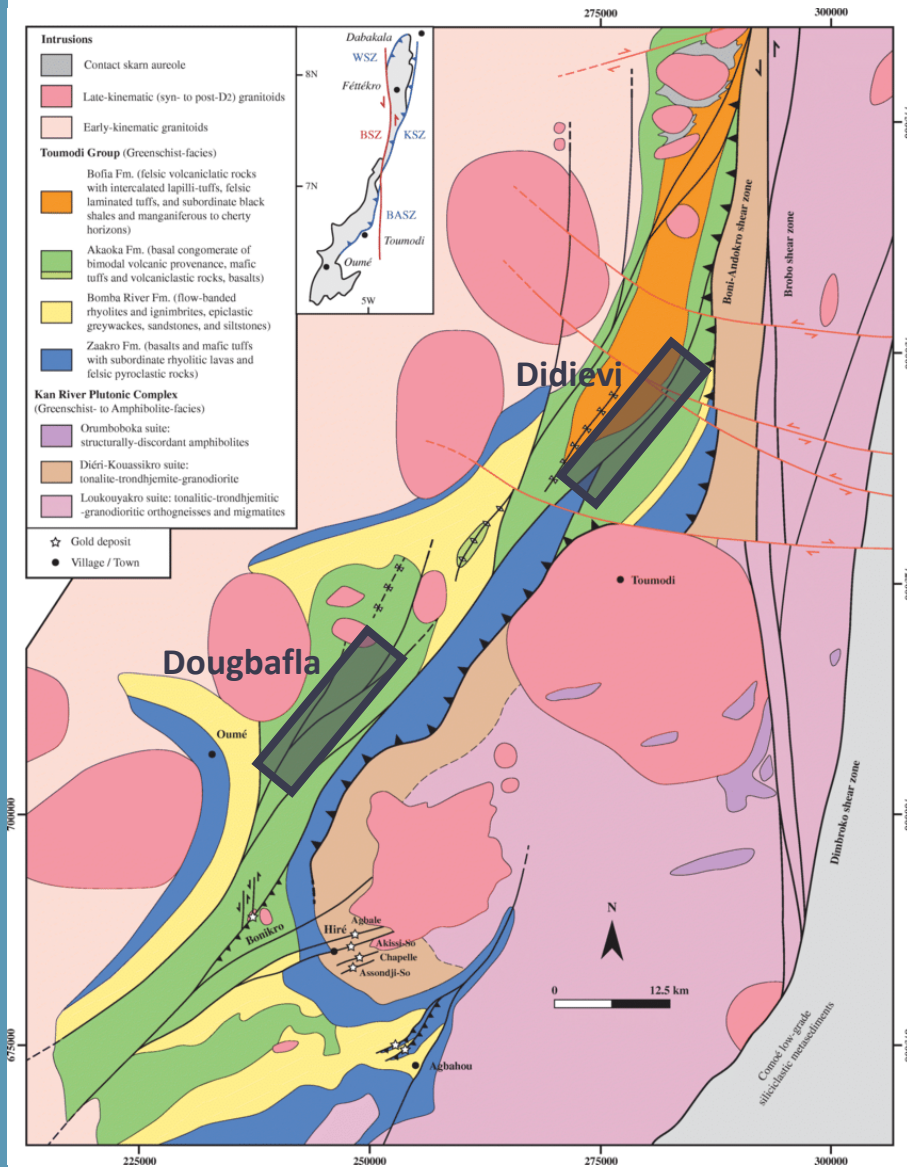
Intrusive Related Gold Deposits



The picture on the left is from the South Wall of the Bonikro pit looking at the porphyritic intrusive fingers in white along with contacts against the mafic volcanic rocks.

The picture on the top is showing the typical sheeted veins associated with the gold mineralization at Bonikro with disseminated pyrite and molybdenite.

Late Brittle Gold Deposits



Deposit characteristics

The third type of deposit found in the Southern Oumé-Fettékro belt are Late Brittle Gold Deposits.

The volcano-sedimentary sequences that host these types of deposits are relatively undeformed, the penetrative regional fabric is not present systematically within these units, generally only developed at proximity of narrow Eburnean strain/shear zones.

Mineralization is structurally controlled but brittle, and generally occur along poorly defined orthogonal fracture zones, locally with the deformation intense enough to create breccia zones.

The most common associated sulphides is pyrite.

Dougbafla-Didievi.

Late Brittle Gold Deposits



The picture on the right is from the Dougbafla West deposit showing mineralization in hole DWDD091 hosted in a narrow felsic intrusive with narrow veins/fractures occurring along preferential fracture planes.

The picture on the top is from hole DD049 at the Didievi project, the brittle style of mineralization is comparable to the mineralization style and structural controls at Allied's Dougbafla deposits, most likely suggesting a distal style of mineralization potentially associated with deep-seated felsic intrusives.





Deposit characteristics

The last type of deposit found in the Southern Oumé-Fettèkro belt are Foliation Parallel Vein System deposits.

The only known foliation parallel vein system deposit found in the Oumé-Fettèkro belt is the Agbaou deposit which is hosted in a deformed and strongly foliated volcano-sedimentary sequence mainly composed of mafic volcanic flows, volcanoclastics and detrital sediments, mostly greywacke with minor horizons of siltstones.

Mineralization is associated with deformed, dismembered and boudinaged quartz veins which have formed, or been transposed, along the main fabric considered to be the regional S1 foliation.

No secondary foliations have been observed at Agbaou.

Foliation Parallel Vein System



Vein characteristics

Exposed veins in the Northern wall of the Agbaou West pit.

The veins are parallel to the main foliation which is the only foliation observed at the Agbaou mine.

The veins have been deformed, folded and boudinaged.

Structural relationships and controls of the mineralized veins at Agbaou are similar to those observed at Wassa and could be an analogue deposit of similar age and tectonic setting.

Gold Deposits Timing – South Oumé-Fettèkro Belt

Allied Proposed Timeline Gold Deposits

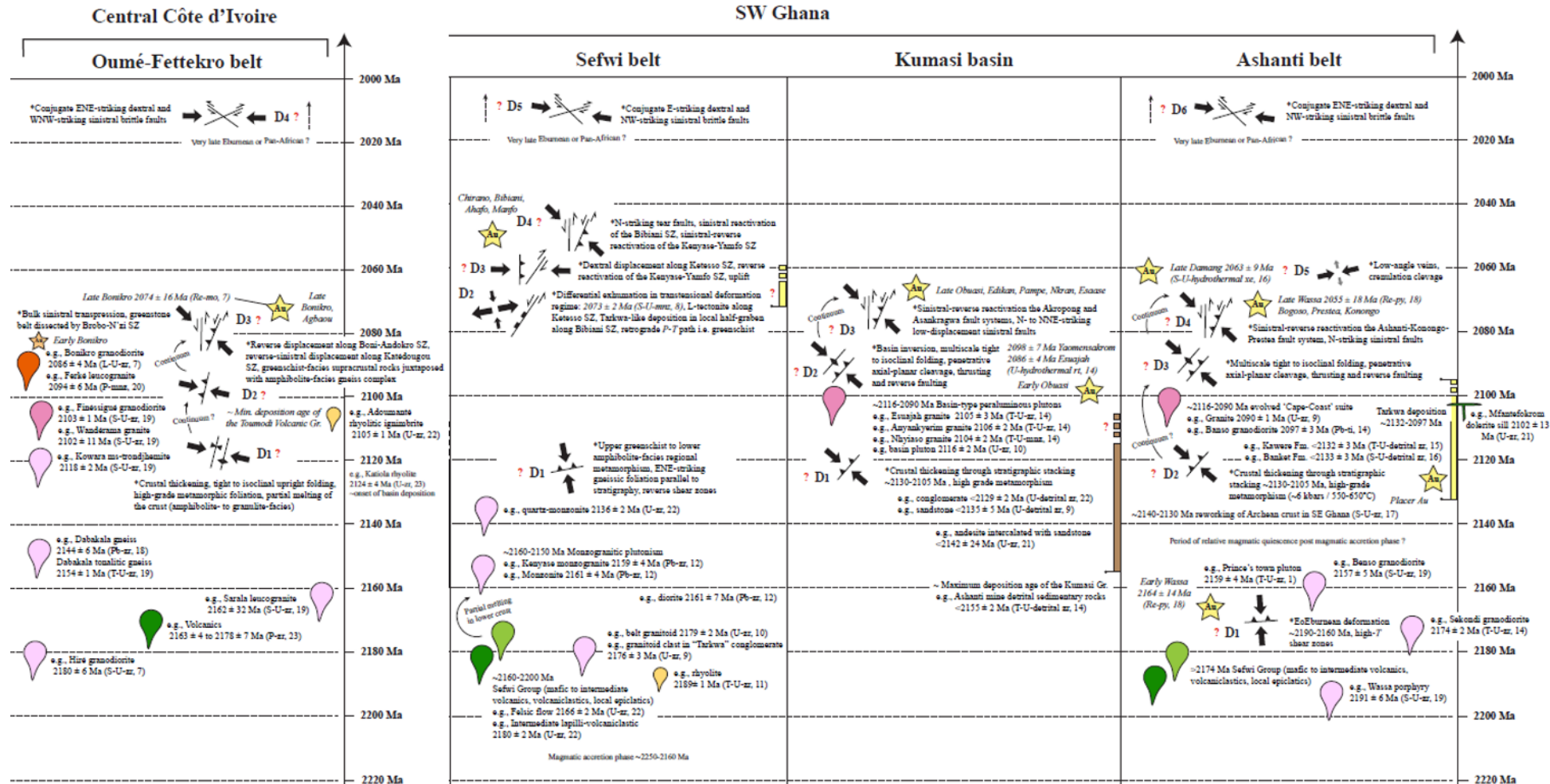
D5: Brittle-Ductile rebound style. Brittle Fault/Fracture
Bonikro Gold – 2074 ± 16Ma
Dougbafla-Didievi gold?

D4: Strike slip ductile-brittle tectonic.

D3: Lock-up of thrust fault, transition to strike-slip
Hire Shear Hosted gold?

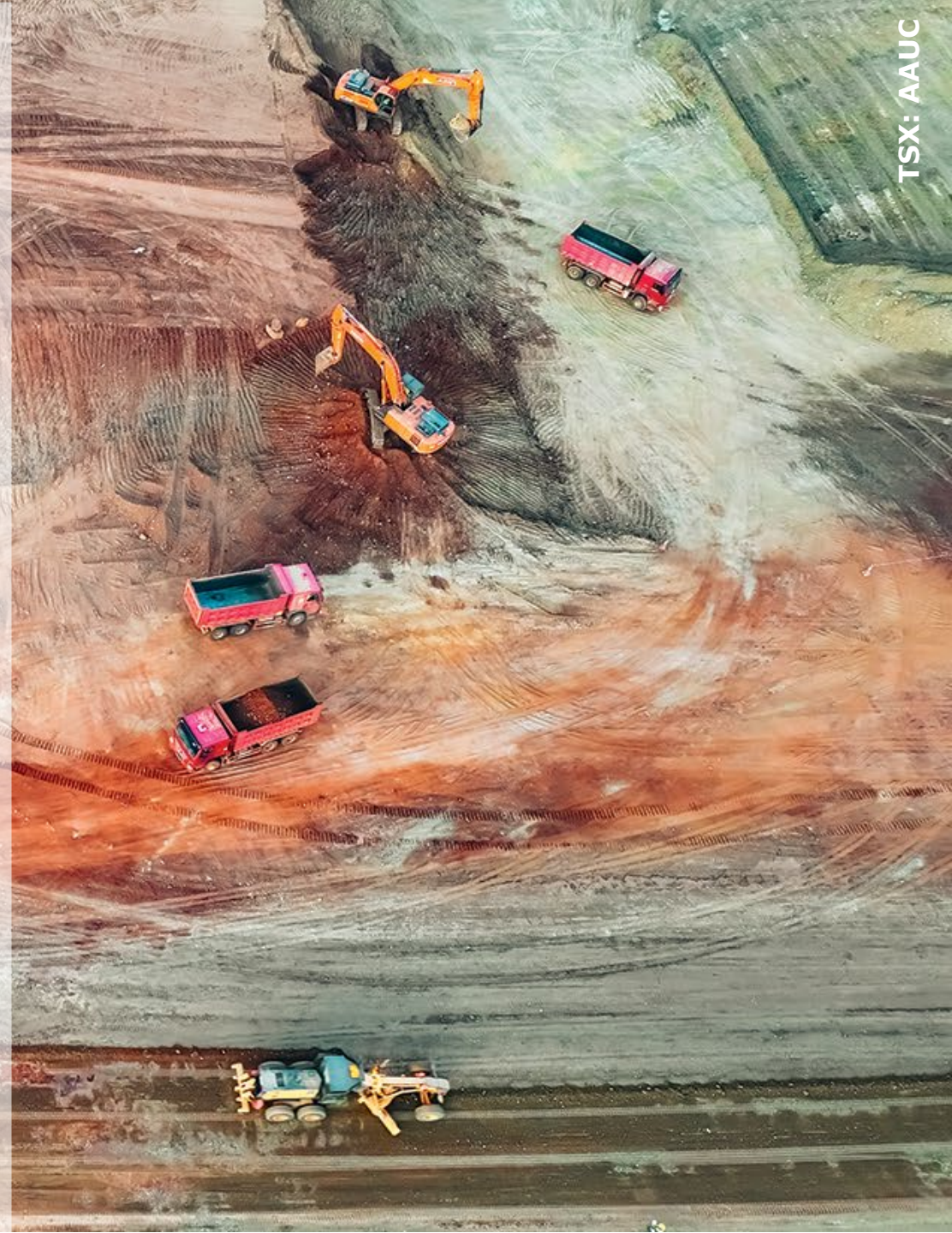
D2: Simple shear – thrust faulting – Dabakala gneiss

Syn-D1 ~2180Ma Hire granodiorite. Thrust/Accretion
Agbaou early gold event similar to Wassa?





Gold Endowment of the Belts and Gold Timing



TSX: AAUC

Gold Endowment of the Belts and Deposits Timings

The South Ashanti Belt is host to a minimum of four distinct gold events including the Tarkwaian Paleoplacers, while only one gold event has been dated in the Oumé-Fettèkro belt with Bonikro at 2074Ma, but we can most likely infer two other gold timing events based on the structural controls of the deposits, but further geochronology work is needed to confirm the absolute gold timings:

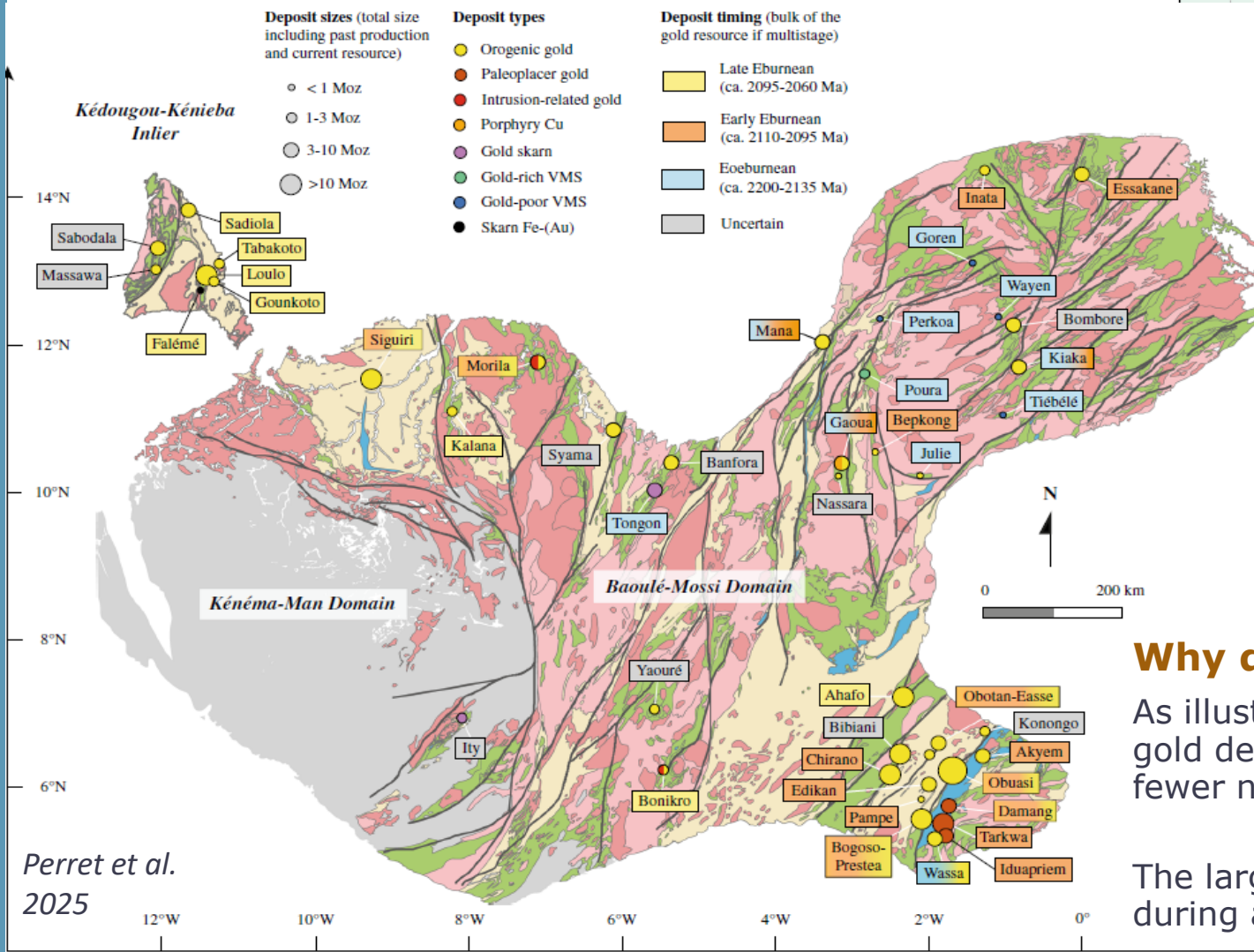
Gold endowment for the South Ashanti Belt:

Eoeburnean Folded Veins Deposits (Wassa)	≈ 10Moz
Tarkwaian Paleoplacers (Tarkwa-Teberebie)	≈ 40Moz
Eburnean Orogenic Deposit (Obuasi-Prestea)	+100Moz
Late-Eburnean Thrust Fault Veins (Damang)	≈ 14Moz

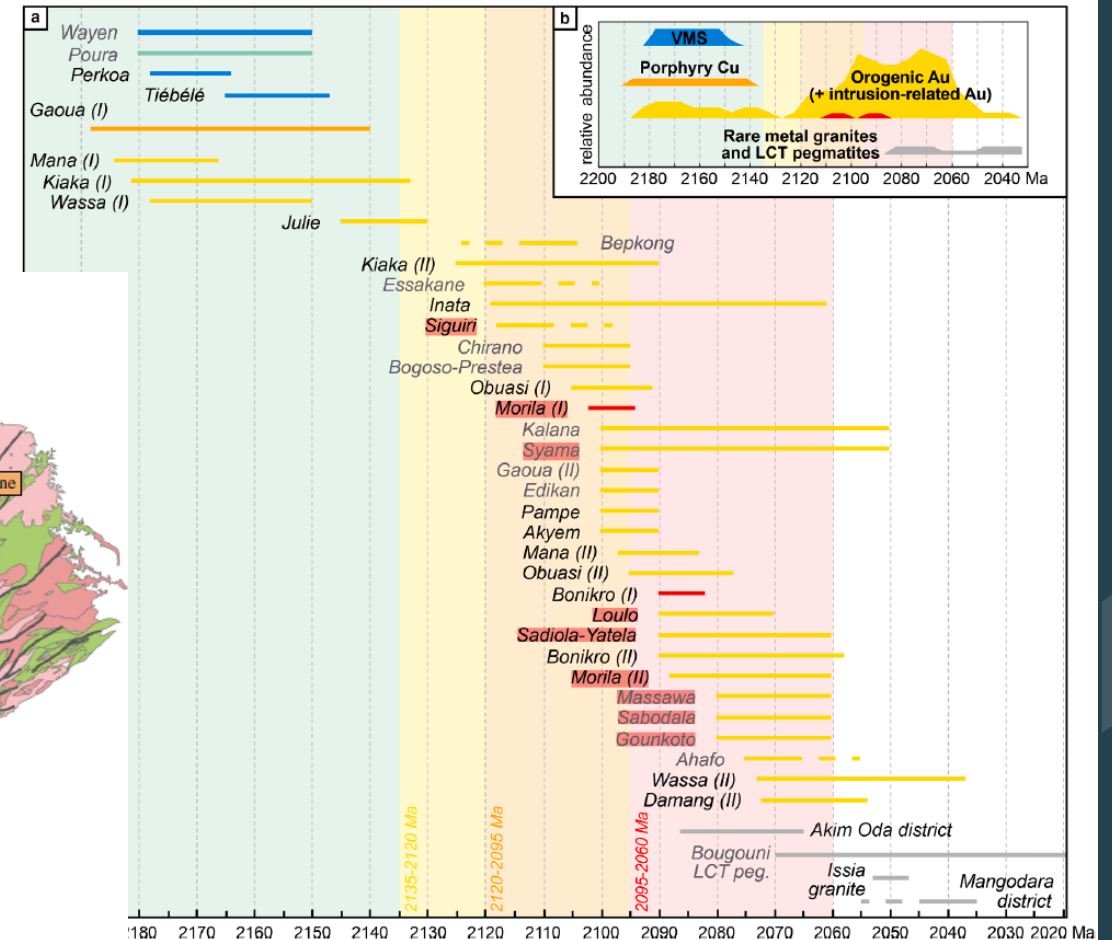
Gold endowment for the South Oumé-Fettèkro Belt:

Eoeburnean Foliation Parallel Veins Deposits (Agbaou)	≈ 2Moz
Eburnean Orogenic Deposit (Hire)	≈ 1Moz
Late-Eburnean Intrusive Hosted Gold Deposit (Bonikro)	≈ 3Moz
Late-Eburnean Brittle Deposits (Dougbafla-Didievi)	≈ 2Moz

Gold Deposits Timings



Perret et al.
2025



Why do Gold Deposits Timings Matter?

As illustrated on the map/table above, a certain number of gold deposits were formed during the Eoeburnean, but in fewer numbers and they are generally smaller deposits.

The larger deposits were, for the most part, all formed during a short period of time in the late Eburnean.

Beyond Deposits Timing: Gold Deposits Endowment versus Juvenile Crust

Epsilon Hafnium Map

This Epsilon Hafnium map was presented by Nicolas Thébaud; we can now observe the respective belts endowment against the Juvenile Crust map with cold colours representing terrains with high juvenile crust content and warm colours representing areas with high levels of crust recycling.

South Ashanti Belt: +160Moz

South Oumé-Fettèkro Belt: $\approx$ 8Moz

How can we use this as an exploration tool?

There are many factors to account for when developing strategies as explorers, factors like operating mines, mine life and mill feed blends must all be accounted for in our strategies.

But in a vacuum, areas characterized by high contents of juvenile crust would theoretically deliver higher probabilities of discovering tier-1 deposits and in greenfield exploration situations, this type of advanced isotope tools and knowing the age of your deposits is essential.

