PRIMARY GOLD MINERALIZATION IN THE IRON FORMATION OR BIF: CASE OF FOKONTANY MANGATANY, ANDILANATOBY COMMUNE, AMBATONDRAZAKA DISTRICT.

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SUMMARY

Currently, gold is a rare metal, the most useful in the world. The mineability grade of gold is a decreasing value, but the price is an increasing value in the future. Madagascar has many unidentified gold deposits due to the lack of geological study of the island. Southeast of Mangatany village, there is an active alluvial gold mine operated by local people called Ambatomainty. The gold site is said to be isolated from geological research compared to Maevatanana, Andriamena, Betsiaka, etc. The first part of the work develops the methodological aspects which focus on the field trip. Observation of outcrops shows that there are two structural signatures in the region: a remarkable schistosity and foliation plane in a North-South direction, cut by a recent formation in an East-West direction. The eluvial survey confirms the existence of primary deposits in the region and the XRF result signifies the absence of gold in the BIF of the gold-prone site studied. The metamorphic facies of the study area presents a gold formation of protezoic age or in mica schist which extends for kilometers towards the North and the South. The recognition of the Ambatomainty sector generates the new geological documentation of Alaotra, especially the gold index of the region. In 2010, the alluvial exploitation of gold deposits by local people has already begun to this day. Knowledge of the petrological and geographical characteristics of this gold sector makes it possible to define the specificities of gold, namely the metallogeny of gold, the primary source.

Keywords: *FF iron formation or Banded Iron Formation (BIF), structural, mesozone, schistosity, foliation, eluvial, XRF, metallogeny, gold-bearing sediment stream, malgachitic charnockites.*

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1. INTRODUCTION

Gold mineralization is exceptionally important so that it reveals processes of the formation of deposits and the evolution of the mechanism and as well as the transport by fluids and vapors, the migration of chemical elements in the Earth.

Metamorphic processes have been involved in the genesis of many major gold deposits around the world, including the gold in the slate belts, the Witwatersrand goldfields in South Africa and as well as the gold deposits in the belts of Archean green rocks.

In Madagascar, in the part of the crystalline base, in 1920, Lacroix began prospecting for gold showings in the crystalline rocks of the gold-bearing regions known in Madagascar, such as the Maevatanana gold-bearing region, in the Betsiaka region, the Vohemar gold-bearing region, in SAVA region, Mampary gold region, in the South East region, Andriamena gold region, Tsaratanana gold region and Dabolava gold region in the West.

The more largely gold-bearing formations are therefore found at the top of the mesozone in rocks with mica schistose facies and in particular towards the migmatite front. Gold visible to the naked eye is abundant, especially in the feldspar zone according to Henri BESAIRIE.

Geological research in the Alaotra Mangoro part was carried out to prove the existence of primary gold, which is disputed by some geologists and obviously other mineral substances like cobalt, nickel, Didy sapphire, Andilamena ruby

On the other hand, the presence of gold in the alluvium of the Anony River encourages researchers to identify primary gold in the massif of migmatites or granitoids to the east of the Anony River.

Upstream of the Marotaolana river, near the village of Mangatany, artisanal mining was carried out by gold miners from Mangatany where they found some clues. The latter pushed us to carry out geological and geochemical studies in order to know the surrounding rocks of the primary gold source of the secondary gold of Marotaolana. And this is the reason for the theme entitled: “Primary gold mineralization in the iron formation: case of fokontany Mangatany, Andilanatoby commune, Ambatondrazaka district. »

2. MATERIALS AND METHODS

2.1. Materials

2.1.1. Location map of the study area

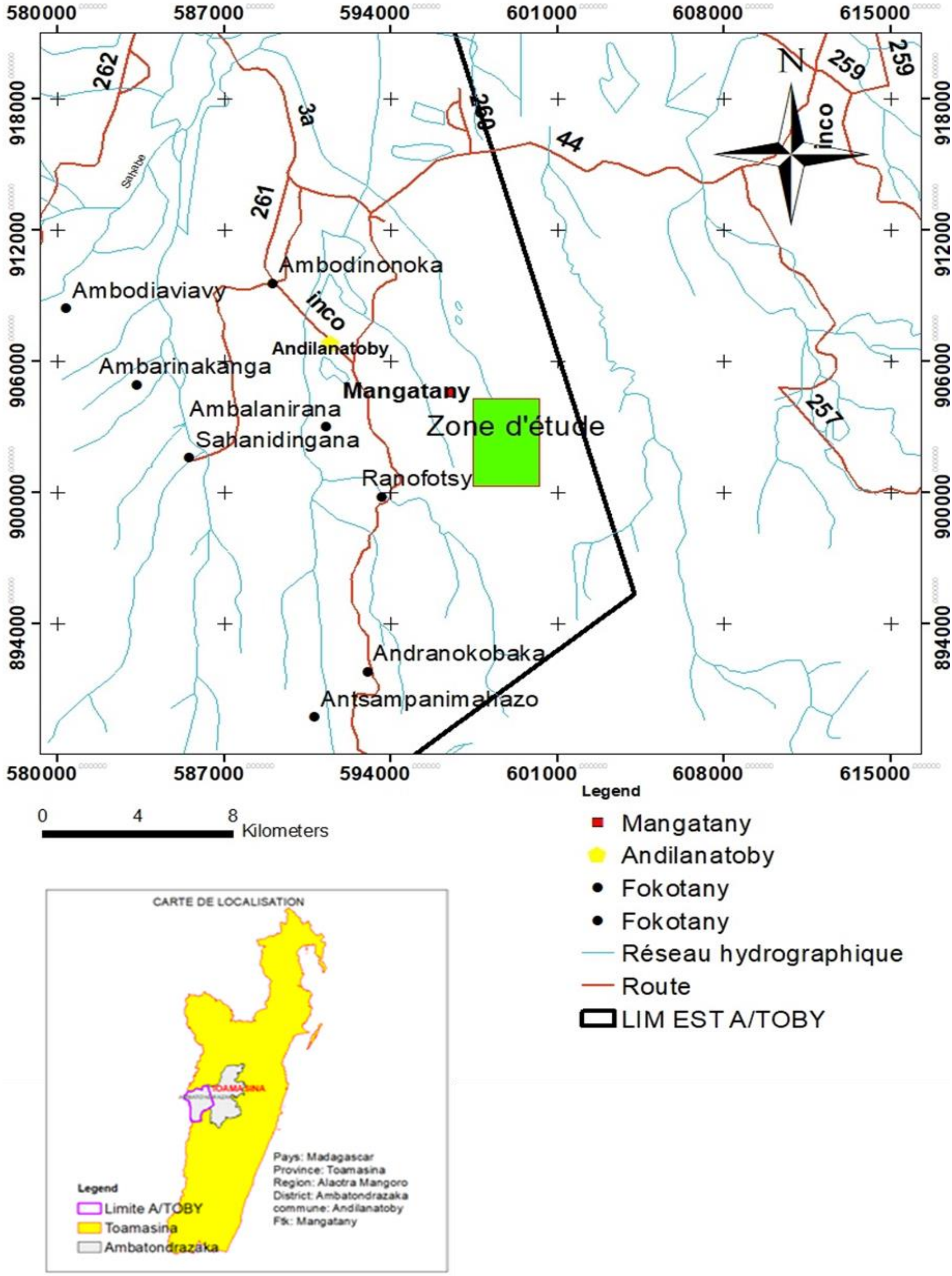


Figure 1: Location map Source: BD 500

2.1.1. Laboratory Equipment

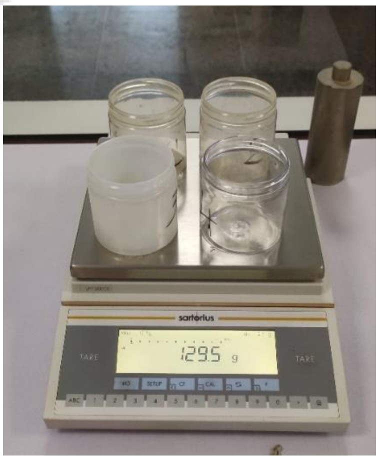
2.1.1 1. Portable XRF

It is a device for detecting chemical elements in rock that can be worn in the field. The SPECTRO
The SPECTRO XSORT portable XRF provides extremely preliminary orientation analyses. And, for more complex matrices such as environmental screening, SPECTRO XSORT achieves very low detection limits without the need for complex sample preparation.
The SPECTRO XSORT portable XRF is also available with convenient and time-saving features, such as a built-in video camera for precise spot testing and visual memory storage. A built-in global positioning system (GPS) is also available that allows you to quickly return to previously checked locations without wasting time.

Photos 2: Portable XRF Source: Laboratory

2.11.2. Hydrostatic balance

Hydrostatic Balance Model: Description HB20 Hydrostatic balance is also called buoyancy balance, it is widely used in geological laboratory for testing density, weighing samples and laboratory products. It is composed of electronic scale and hydrostatic assembly, conversation of units, calculation with tare.



Photos 3 : Balance de précision

Photos 4 : Balance électronique Source : Auteur

2.1.1.3. Silite Furnace

- ✓ Automatic temperature regulator with instantaneous value indication with proportional action – Thermocouples;
- ✓ Very effective thermal insulation, resulting from a combination of silico-aluminous refractories and ceramic fibers, which made it possible to obtain reduced energy consumption and rapid heating, without altering the duration of the coating with prolonged operation;
- ✓ Kanthal A1 alloy resistors;
- ✓ Welded steel construction protected against corrosion;
- ✓ Automatic heating shutdown when the door is opened;
- ✓ Rear smoke exhaust towards the door cover connected to the suction fan, with manual and automatic control.
- ✓ Refractory steel soles on all models except FM 76H.

Optional equipment:

• Digital temperature display
• Time introducer
• Temperature cycles controlled over time
• Automatic programming of thermal cycles
• Standard power supply: 220V single-phase, 220V three-phase, 380V three-phase with neutral
Preheating time: 70 minutes
Energy consumption at 1000°C: 0.8 KW

Photos 5: Four à Silite (FM 76 S) Source : Auteu

2.1.1.4. Separation hood

The hood is made entirely of self-extinguishing PPS polypropylene and is equipped with internal lighting.
Depending on the model, the hoods can be equipped with:
• Two systems for multiple dosages, one for HNO3 at 22°Bé and one for HNO3 at 32°Bé (Baumé degree), each adapted to contain a quartz container for 24 dosages. Both systems are constructed entirely of Pyrex glass and equipped with a condenser, relative heaters and a 1200 watt power variator.
• One or more 1700 W electric cell ovens with variable power allowing 6 tanks to be heated at the same time;
• Two Pyrex glass containers with lid, one for HNO3 at 22°Bé and one for HNO3 at 32°Bé, equipped with a 2000 watt electric heating plate and a power variator;
• Sink for washing bottles;
• Acid recovery container with stainless steel drain.
Table 2: Technical data
CS/B1
- Single phase regime
- Power 3Kw
  - 6 places ovens n.2
  - Pyrex containers -

- Flow YES
- Overall dimensions (mm) 1500x600x2300

Photos 6: Hotte de séparation Source : Auteur

2.1.1.5. Rolling mill

This machine has three important features: a hardened steel anvil for crushing metal samples, a motorized rolling mill (with foot control) equipped with 52x100 mm rollers, and a small electric heating plate.
Technical data :
• Power supply: three-phase
• Power: 380V
• Overall dimensions: 113x54x97 cm (length-width-height)
• Weight: 175kg

Photos 7: Laminoir Source : Auteur

2.1.1.6. Laboratory XRF

XRF Technical Data: helmut fischer-goldscope sd 510

- **Utilisation prévue**	**Instrument de mesure à rayons X à dispersion d'énergie (EDXRF) pour analyser les métaux précieux**
- **Concevoir**	GOLDSCOPE SD 510: Unité de paillais avec vers le capot ouvrant vers l'avant,
- **Alimentation et consommation d'énergie**	AC 115 ou 230 V, 50/60 Hz, max. 120 W sans PC d'évaluation
- **Classe de protection**	IP40
- **Température de fonctionnement**	10 °C – 40 °C / 50 °F – 104 °F
- **Température de stockage/transport**	0 °C – 50 °C / 32 °F – 122 °F
- **Humidité relative**	≤ 95 %
- **Positionnement de l'échantillon**	Manuellement
- **Microscope vidéo**	Caméra couleur CCD haute résolution pour la surveillance optique de l'emplacement de mesure le long de l'axe du faisceau primaire, réticule avec une échelle calibrée (règle)et un indicateur ponctuel, éclairage LED réglable
- **Facteur de zoom**	Numérique 1x, 2x, 3x, 4x
- **Ordinateur**	Windows®-PC
- **Logiciel**	WinFTM® optimisé pour GOLDSCOPE SD, y compris Gold Setup GOLDSCOPE avec applications de mesure pour l'or et les bijoux
- **Normes**	EN 61010, EN 61326; DIN ISO 3497 et ASTM B 568
- **Approbation**	Instrument entièrement protégé avec homologation de type conformément à la législation en vigueur en matière de radioprotection
- **Poids maximal de l'échantillon [kg/lb]**	13/29
- **Zone de placement de l'échantillon utilisable [mm/in]**	305 x 490/12 x 19,3
- **Hauteur maximale de l'échantillon [mm/in]**	130/5.1
- **Dimensions externes : Largeur x profondeurs x hauteurs [mm/in]**	405 x 588 x 426/16 x 23 x 17
- **Poids [kg/lb]**	environ. 45/99
- **Tube à rayons X**	Tube de tungstène stabilisé thermiquement
- **Haute tension, trois étapes ;** - **Courant d'anode max**	30, 40, 50 kV
- **Couverture (Collimateur) Ø [mm/mils]**	Fixe Norme 1,0/39 Option 0.6/24;
- **Plus petit point de mesure* Ø [mm/mils]**	environ. 0,7/28
- **Type de détecteur**	Détecteur pin en silicium refroidi par Peltier
- **Résolution fwhm pour Mn-Kα [eV]**	≤ 180
- **Temps de mesure**	60 sec

Photo 8 : XRF de Laboratoire **Source : Auteur**

2.2. Methods

The execution of our study is divided into three methods: the first presents the preparatory and documentation studies, the second lists the field studies, and the third devotes to laboratory studies.
2.2.1. Bibliographic analysis
The documentation phase is a very important part of the study which facilitates the research work, avoiding surprises in the field. Thus, pre-existing documents provide background knowledge for new researchers. Tactical documentation with many advantages to facilitate researcher tasks, guide for juniors, references. The essential ideas relating to our theme are listed in general.

2.2.1.1 Descriptions of Gold.
Gold is a rare or noble metal among the metallic substances of Clark 5mg/t, comes from the Latin word aus, aurum. It has been used by humans since the end of prehistory in the form of jewelry. In contemporary times, it has also served as a monetary standard alone or with silver. The attempt to find the source of gold mineralization in this study area is mainly focused on the geochemical method using "Stream sediment" remains the most suitable method for prospecting for gold, so much so that gold is very mobile when detached from their primary training.

Photo 9 : Or **Source :** https://www.goldlineorpaillage.fr

Physical properties

Gold has a brilliant yellow color; it is a heavy metal; its density is 15 to 19.32. It is malleable, ductile, with a hardness of 2.5 to 3 and can be reduced to very thin sheets by beating. The gold thus reduced to its leaves allows a green color to pass through, a complementary color to the red reflected by the gold. The melting point of fine gold is 1045°C. It then has a blue-greenish color. By cooling it contracts a lot. Gold crystallizes into regular octahedrons or rhomboidal dodecahedra and other shapes derived from the cube. Precipitated by iron sulfate, gold gives a brown color. Suspended in water, it gives off a blue-purplish color.

Chemical properties

Gold has the symbol Au, and its atomic weight is 196.6. It resists the action of air and water in all conditions, and is unassailable to nitric, hydrochloric and sulfuric acids. The mixture of the first two of these acids, which is called aqua regia, dissolves gold very quickly. Chlorine and bromine also dissolve it quickly. Alkalis have no action on gold; However, when gold and an alkali are heated, in the presence of air, there is little by little absorption of oxygen and formation of an alkaline urate. Gold in fine particles is quickly dissolved by potassium cyanide. It is sometimes associated with elements such as copper, cobalt, silver, chromium, tin, uranium, molybdenum, tellurium, mercury and more rarely with bismuth, iron, palladium, rhodium and platinum.

Gold Ores

Metallic ores which often contain gold are: arsenical pyrites, iron pyrites, galena, blende, variegated coppers, gray coppers and antimony sulphide. But most of the gold comes from alluvium and then from quartz veins. Alluvium is formed of sand or clay and rocks or fragments of rock, siliceous or granitic, disintegrated by water and air and carried from the top of the mountains by the water. As we often find gold still embedded in its quartz matrix, there can be no doubt about the origin of these alluviums.

Gold found in alluvium in the form of flakes or grains. The latter when they exceed a certain volume are called nuggets; nuggets weighing several kilograms are known. In quartz, gold is in small grains or veins, but most often in fine particles invisible to the naked eye.

Quartz veins generally cross talcose shales, micaceous or amphiboliferous shales, granites, porphyries, serpentine.

Gold mineralization

By definition, mineralization is a concentration of metallic or non-metallic minerals by the endogenous or exogenous geological process. That is to say, gold mineralization belongs to the collection of Gold in a geological layer capable of being exploited. Several processes form gold mineralization according to the documents we consulted.

Volcano-sedimentary sulphide clusters and exhalative-sedimentary deposits

The Franklin Gyot is an andesilico-basaltic submarine volcano located in a continental margin area, in the extension of the axis of the oceanic opening of the Woodalle basin. Recent mineralized deposits appeared at the end of volcanic activity after the formation of a central caldera. They include very widespread oxidized facies with Fe, Mn, Si, as well as barytic facies rich in Ag (545 ppm) and Gold (21 ppm) containing significant quantities of Zn, Cu and Pb. Barytic facies were encountered in the form of two inactive chimneys located in the caldera [1].

Gold conglomerates

The Archean bedrock of the Watersrand hinterland is mainly made up of granitoids affected by hydrothermal alteration (propylitization, serietization, carbonitization and greisenization). The altered zone which shows a significant enrichment in Au and U, would represent the apical part of shallow intrusions which would have been put in place during sedimentation and more precisely, before the deposition of the upper part of the detrital series, particularly rich in Gold and Uranium. The authors assume that the erosion of these alteration zones could have contributed significantly to the supply of these metals to paleoplacers [2].

Mesothermal deposits

The Flin Flon domain, in northern Saskatchewan and Manitoba, contains numerous small-scale mesothermal gold occurrences; This is a vein of quartz or gold associated with pyrite and arsenopyrite, placed in the ductile shear zone taken up by ductile, brittle movements during the rise of the building subsequent to the peak of metamorphism. Several arguments, in particular the reduced extension of hydrothermal alteration, the low mineral contents in Gold. The absence of S-type granitic intrusion and mantle-derived lamprophyres suggests that limited volumes of fluids percolated through the shear zones and that these are therefore not transcrustal structures capable of hosting major deposits. [3].

Deposits of porphyry systems (Cu porphyries, gold skarns)

The district of Gunung Bijih (Ertsberg) located in the central chain of Iran Jaya, includes several Skarn-type deposits associated with the Pleocene dioritic intrusion of Ertsberg placed at 2.9 Ma in a carbonate series of tertiary. This article gives a geological description of three main Copper-Gold Skarns; Ertseberg(33 Mt at 2.5% Cu and 0.8%), GBT (100 Mt at 2.1% Cu and 0.8 g/t Au), and Dom (31 Mt at 1.5 Cu and 0. 4g/t Au).(Mertig H.J [4].

Epithermal deposits

This deposit is one of the most recent and most important discoveries made in Indonesia since it contains 100 t of Gold and 1000 t of Silver. It was found following exploration work by the state company Ducka Jambang (1998-1991) in a series of tertiary andesitic volcanics. It is one of the bundles of four NW-SE veins of adular sericite type with quartz, adular carbonates and clays containing a small quantity of sulphides (approximately 1%), mainly pyrite and some base metal sulphides, the precious metals are in the form of electrum and argentite [5].

Supergene alteration deposit

The Igarapé lateritic deposit is located in the eastern part of the Amazon Shield. The source rocks, which belong to the Rio Fresco group of Upper Archaean age (volcano-sedimentary series with intercalation of ferruginous quartzite) are of chloritized hydrothermalized facies, sericite, carbonates and silica. The highest contents are located in the armored horizon of the upper part of the profiles where native gold and electrum are intimately associated with goethite. The distribution of Gold in the profile and morphology of the seeds suggests that gold was remobilized and precipitated in laterization phenomena [6].

Gold deposits in the iron formation

Banded Iron Formations (FF) or Banded Iron Formation (BIF), first defined by James (1954), are fine bedded or laminated chemical sediments, consisting of at least 15% iron of sedimentary origin. generally interbedded with chert.

Iron formations are divided into four categories according to their primary facies, are oxide, carbonates, silicate and sulphide. There is a general consensus on the origin of oxides, carbonates, and silicates, namely that they come from chemical and/or detrital marine sediments [7].

Two types of iron formations were distinguished by Gross (1995): the upper lake type with an epicontinental sedimentary character, and the Algoma type, present in volcano-sedimentary rock belts. The first was deposited between 1.8 and 2.3 Ga, in a continental platform environment in passive margins, in response to the oxygenation of the oceans (global processes), and forms sequences extended over hundreds of kilometers; the second is mainly Archean to Paleoproterozoic, enclosed in green rock belts, and forms tens of kilometers having been deposited thanks to exhalative processes from a local volcanic center [8].

Gold deposits in the iron formation are typically associated with Algoma-type iron formations [9].

Primary gold deposits of madagascar

 Andavakoera gold deposit

The presence of quartz beds intercalated in the shales is probably gold-bearing. This differs from the Andavakoera gold deposit which mines electrum because of their origin. The hydrothermal solution takes advantage of the appearance of breaks. The Andavakoera deposits are, says M. A. Lacroix, quite remarkable from the theoretical and practical points of view; they differ from all known and studied deposits: by the composition of their gold, which is very silver-bearing; by their vein-like character; by their age, finally, which is much more recent, at least post-Triassic. Fractures are caused by tectonic movements which strike this sedimentary zone leaving breaks). The acidic solution composed of very thin quartz veinlets takes advantage of the breaks to solidify them and put them in place. Y. BRIERE mentions that this quartz is not compact; it still has the jaw structure, that is to say that, on the walls of the cracks, the quartz crystals are implanted almost normally and end in short birhombohedral points: characteristic structure of a hydrothermal formation. Many of the veins do not carry gold or sterile but other minerals such as barite, blende, pyrite and sulphides. Mr. de LAUNAY, relying on the parallelism of the gold veins and the rock dykes eruptive rocks, on the presence of thermal springs, following the breaks, thinks that these deposits are in a genetic relationship with eruptive rocks.

Formation period of the primary gold deposits of madagascar

Generally, Madagascar's primary gold deposits form over three periods

 Primary archaeal deposits

Mineralizations most often appear in the form of interstratified veins:
- Associated with series of basic amphibolic rock: Maevatanana, Andriamena, Alaotra, Ampasary.
- Associated with magnetite quartzites: Maevatanana, eastern cliff to the South of Antananarivo and the South-East, more incidentally Andriamena and Beforona-Alaotra;
- Associated with silico-aluminous series of the Ambatolampy-Andriba type (quartzites, gneisses, migmatites, aluminous and often graphitic mica schists): typical regions of Ambatolampy and Andriba, West Antananarivo, Sahantana and Vavatenina series, plus incidentally series of Mahambo and Vohilava-Ampasary and South-East.

Superimposed on these three types is a type linked to late granitoid intrusions which locally affect the facies listed above, by remobilization of the gold stock, in the form of peribatholitic veins, stockworks and diffuse mineralization in the tactites. The interference of intrusive phenomena with the old carrier series constitutes the most favorable metallotect.

 Primary cottages of proterozoic

Gold is at the micaschist or quartzite facies of the series "Schisto-quartzo-limestone" (SQC), transformed either by a regional metamorphism, or by an intrusive contact metamorphism. They most often appear in the form of disseminations of railway sulfides.

The two best-known typical cases are:

• The Betsiriry region (eastern Miandrivazo) where the gold clues are gathering in the passing area between the migmatitic gneiss and the epimetamorphic series "Schisto-quartzo-limestone" (migmatite front);

• The Itasy region where the indices align in the more or less silicified formations (tactitis) bordering the intrusive granite massif of Itasy.

 Primary lodgings linked to permo-trial tectonics

These are real veins, made up of quartz-barytical fractures, with native gold and associated sulfides. This type is only found on the Bordure Socle-Sédiment of the northern end of Madagascar, over a hundred kilometers between 'the Sambirano valley and the east coast.

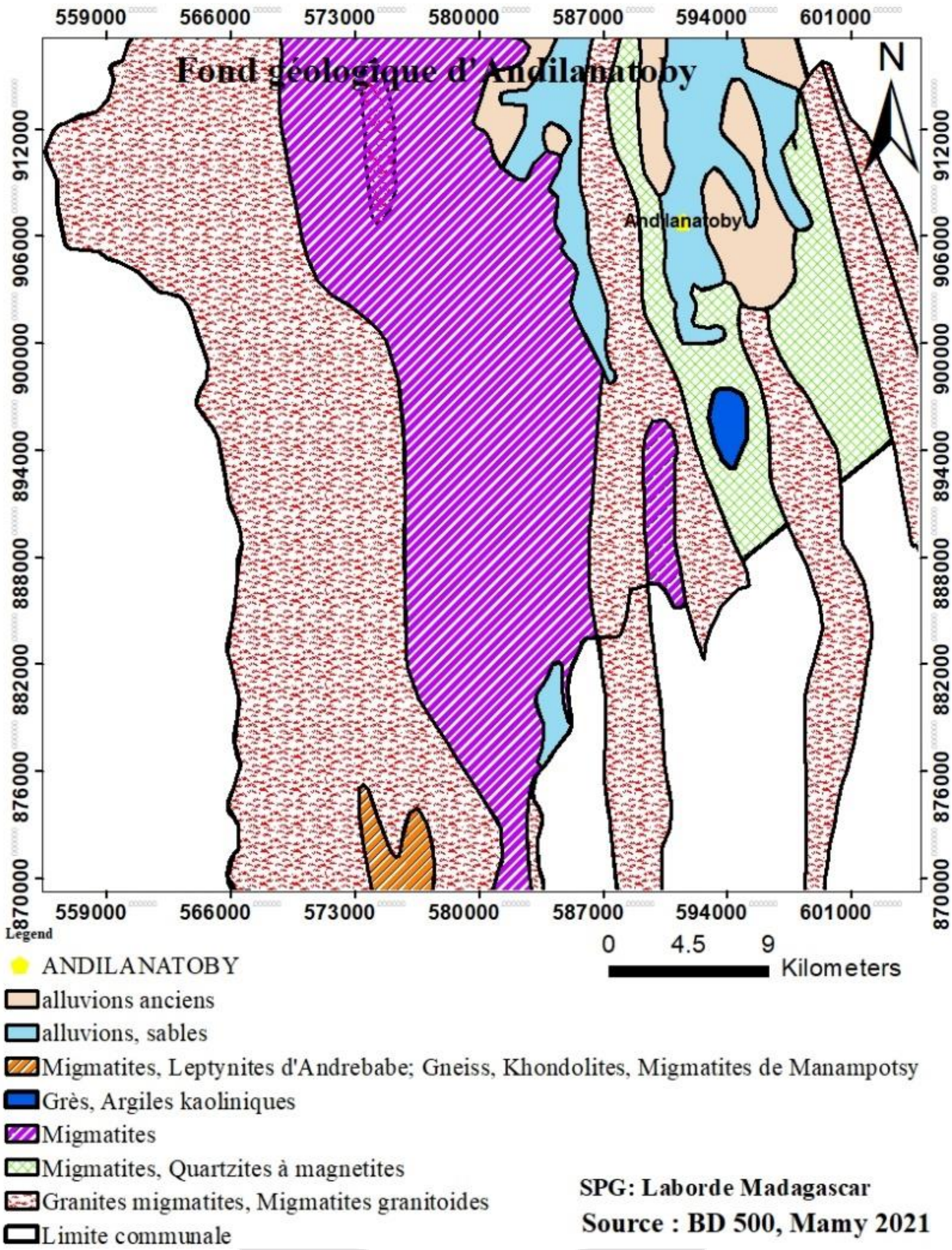
In the condition of gold deposit formation, it is divided into two forms: primary deposits and secondary deposits. Secondary deposits are the most recognized for the exploitation of gold in Madagascar.

Geology of the study area.

The geological history of the region mentions that the vast plains of rice cultivation of Alaotra is to deposit old precambrian sedimentary formations of the Androyen system, followed by intrusions from the successive series of the eruptive rocks of the Androyen system (Granites, Gabbros). During these geological times, deep tectonics with migmatization and general metamorphism results from unequal intensities. Deep Malagasy Charnockitis Facies with a few leptynites of gneissic and amphibolic facies then mesozone facies with micaschists and quartzites are noticed today, without any epizone facies (Brenon, TBG n ° 8).

Powerful erosion and rejuvenations of the reliefs can specify to the tertiary vertical dislocations perhaps replaying old flaws, which then led to the collapse of the Alaotra. Recent volcanic flows have left traces (ankaratrites). The yellow sands are the covers of the more dominant soils in the region, the source of sedimentary deposits.

Laterization and alteration are the dominant geological phenomena all the crust, leading the appearance of clays in the region. Deforestation quickly accelerates erosion in the Alaotra region. Lavakization is the more remarkable sign due to soil erosion, the sludge is deposited in the low altitude area during the summer season, destroying cultures. No fossiliferous deposit is known in the region, but their appearance must be taken into account in future research work or in civil engineering.



2.2.2. Work on land

Gold is placed in Bed Rock or Allochthonous soil during the rain of anterior year.

 Identifying alluvial gold clues in the river

The presence of goldsmiths facilitates the investigation of "inheritance stream" or alluvial prospecting in the bed of the Marotolana river, because the anomaly of their gold production is listed in the study site. And the latter allows us to track down the rocking rocks or associated with the surroundings of the river.

 Subscribe prospecting

Subsearch prospecting is oriented in the soils of the colluvial area of the mountain of Ambatomainty. The samples taken from this place are intended to be justified as associated rocks of gold. The importance of this survey is to find gold first in the colluvial area. The sampling of detrital soil samples is carried out at the side of the mountain side, which pours into the gold stream. The sampling was taken according to the altered areas above the workplaces of goldsmiths (Stream) on the site.

The difference between these two prospecting methods is the places where the samples have been taken (alluvial: taken from the river, as for Éluvionaire: at the side of the ambatomainty mountain).

3. Results

3.1 XRF portable analysis result

XRF analysis shows different chemical elements in the rock with a 0.5ppm detection limit, it presents a surface percentage. The result is limited by the speed of X -radius propagation, the surface hit and the high detection limit. This analysis is looking for chemical elements in the rock so that there are relationships for the promotion of the formation of gold gites.

Table 1: Portable XRF analysis results

Eléments detectés (%) ➡ Echantillons ⬇	Si	Fe	Al	Mn	Ca	Mg	Ti	Cr	V	P	K	Zr	Te	y	Co
BIF	26,7	18,56	5,38	4,81	2,53	0,56	0,41	0,24	0,15	0,08	0,07	0,013	<0,11		
Gneiss hautement altéré		10,5		0,72				0,79				0,083	<0,15	0,005	
Gneiss migmatitique		12,8		0,23			0,63	0,62				0,021	<0,15		< 0.057
Feldo-Quartzite à magnétite		4,69		0,05			0,5	0,58	0,26			0,047		0,013	
Latérite rouge		6,17					0,52	0,46	<.030			0,009	<0,12		< .036
Classification géochimique	**Eléments majeurs**			**Eléments mineurs**			**Eléments en trace**							ND	

There are three identical elements that are observed in all samples such as Fe (major elements), Cr (trace elements) and Zr. They show the dominance of iron in the rocks observed except the bif which has an increase in silica levels. There is a mn in the bif, highly altered gneiss, migmatitic gneiss, feldo-quartzite with magnetite except in non-defined red laterite; They present any trace of Ti except in the highly altered gneiss and the tellure but it is not defined in the feldo-quartzite in magnetite. YTTRIUM is detected only in highly altered Legneiss, Magnetite Feldo-Quartzite and the cobalt appeared only in the migmatitic gneiss, red laterite. The vanadium defines in the bif, the magnetite feldo-quartzite, red laterite. Silica, aluminum, calcium, manganese, phosphorus and potassium only defined in the bif.

The bif constitutes by several chemical elements such as 26.7% silica, 18.56% iron, 5.38 aluminum, 4.81 manganese, 2.56% calcium, 0.56% magnesium, 0.41% titanium, 0.24% chrome, 0.15% vanadium, 0.08ù of phosphorus, 0.07% potassium, 0.013% zirconium, Tellure<0.011%.

The highly altered Gneiss defined 10.5% iron, 0.72% manganese, 0.79% chrome, 0.083% zirconium, Tellure<0.015%, 0.005% yttrium.

The migmatitic gneiss constitutes by 12% iron, 0.23 manganese, 0.63% titanium, 0.62% chrome, 0.021% zirconium, Tellure<0.015%, cobalt<0.057%.

Feldo-Quartzite with magnetite constitutes 4.69% iron, 0.05% manganese, 0.5% titanium, 0.58% chrome, 0.26% vanadium, 0.047% zirconium, 0.013% yttrium.

Red laterite 6.17% iron, 0.52% titanium, 0.46% chrome, vanadium< 0.030, 0.009% zirconium, Tellure<0.012%, cobalt<0.0036%

3.2. Fire Assay analysis results

According to this analytical procedure, we can find the exact quantity of gold in rocks, it shows us the final objective of the study for the search for the source of the inheritance of the Ambatolampy area. There are two yields from the Laboratory XRF detector and the Inquartation (Table 2).

Table 2: Coullation analysis results

Reférence → Echantillons ↓	Carbonate (NaCO3) en g	Borax (Na2B4O7) en g	Litagirio (Pbo) en g	SalNitro (KNO3) en g	Farine en g	Argent pure en mg	Echantillons en g	Scorie de Plomb en g	Poids de l'Or XRF en mg	Rendement en g/t	Poids de l'Or en balance en mg	Rendement réelle en g/t
BIF	28,008	16,1	33,02	15,01	30,02	30,4	30,0053	29,7	0,886	28,86	900	30
Gneiss hautement Altéré	28,01	16,08	33,01	15,01	30	29,99	30,0074	28,5	0,202	6,954	170	5,33
Gneiss migmatitique	28,021	16,003	33,02	15	30	30,22	30,0009	30,1	0,029	0,954	0,01	0,33
Feldo-quartzite à magnetite	28,003	16,09	33,03	15,01	30,01	30,27	30,0016	28,9	0,023	0,78	0,01	0,33
		résultat final										

The four samples show the appearance of primary Gold in the rock with different contents.
As well as in the 30.0053 g of BIF shows: 0.886 mg of Gold with a yield of 28.86g/t by XRF and 900 g with a yield of 30 g/t by inquartation.
As well as in the 30.0074 g of highly altered gneiss shows: 0.202 mg of Gold with a yield of 6.954g/t by XRF and 170 g with a yield of 6.974 g/t by inquartation.
As well as in the 30.0009 g of highly altered gneiss shows: 0.029 mg of Gold with a yield of 0.954 g/t by XRF and 0.01 g with a yield of 0.33 g/t by inquartation.
As well as in the 30.0016 g of Feldo-quartzite with magnetite shows: 0.023 mg of Gold with yield 0.78 g/t by XRF and 0.01 g with yield 0.33 g/t by inquartation.

4. DISCUSSION

4.1. Gold deposit in the iron formation (FF) or BIF

The appearance of Gold in the iron formation with a grade of 28 g/t allows us to say that the BIF is a primary gold deposit of Ambatomainty. Gold is deposited in the iron formation in a microscopic or homogeneous state in compact rock, requiring treatment to recover it. BIF has a massive holomelanocratic structure because of the ferromagnesian elements Iron, Mn, Mg, Cr; no sign of fusion anatexia because no defined metamorphic minerals are found, but only basaltic prismation under pressure, after the location of the rock. The formation of iron results from the basic magmatic rise, because the silica content is lower than the sum of the basic elements and especially the absence of Si in the surrounding rock.
Two (02) possible cases as a source of Gold in the iron formation:
- first case, under the effect of the property of siderophiline gold having the affinity with Chromium, Iron, Tellurium, the magmatic liquid brings gold to the surface by forming gold-bearing BIF of Ambatomainty during cooling ; it is syngenetic Gold.
- Second case, under the effect of the temperature of the magmatic liquid, the aureole of the gold-bearing surrounding rock merges and the magmatic liquid is enriched during the passage through the gold-bearing gneiss of Ambatomainty. It's epigenetic Gold.
The presence of Cr and V in the Iron formation marks the volcanic phenomenon in the study area which results in the rise of basic lava in the sedimentary zone of Alaotra.
Therefore, the banded iron formation is the derivative of the volcano-sedimentary phenomenon or the Algoma type.

Photos 11: BIF on the ground Source: Author

4.2. Highly altered gneiss

Altered gneiss is a justified source of the secondary gold deposit in the study area according to the result of 5.33 g/t in table no. 2.

Under the action of the metamorphic and alteration phenomenon, the rocks are totally crushed and highly altered with a tortured structure. The grain shape of the minerals broken up in the rock shows the effect of pressure in the research area. This structure facilitates the release of gold grains in the rock under the action of rain and runoff water, the gold moves very quickly enriching the secondary deposit in the Marotaolana river. This cycle of sedimentation phenomenon ensures the profitability of secondary deposits just after the rainy season in the study area. The highly altered gneiss consists of biotites, feldspar, muscovite, quartz, chlorite interstratified by quartz veins and chloristoschist. Gold crystallizes in the form of a small homogeneous ball which disseminates in a diffuse and homogeneous texture in the rock; which indicates that gold ores are formed by magmatic or syngenetic segregation. The size of the gold in the area proves that the gold deposit is located in the grinding zone or affected by faulting. Little sufficient space allowing the combination of gold minerals in the magmatic liquid to form grains during the solidification of the protolites.

Photo 12: gîte d'altération Source : Auteur

4.3. Amphibolitic migmatite

In the first case, gold is associated with the magmatism of deep domains. Due to its siderophilic nature, gold has an affinity with basic and ultrabasic rocks where it is regularly found at low grade. Gold grains are uniformly dispersed in the supporting rock during crystallization of the original rock, gold minerals unite to form very fine, macroscopic gold grains during magmatic differentiation. It is a magmatic deposit of early crystallization.
Gold is located in the amphibolic series, in particular in amphibolic migmatite and mica schist which are protolites, with different modes of metamorphic formation such as mica schist in mesozone and migmatite in the catazone.
Amphibole migmatite is gold-bearing but low in content compared to mica schist.

Photo 13 : migmatite à hornblende Source : Auteur

4.4. Feldo-quartzite to magnetite

Generally, mineralization appears in the form of discontinuous feldo-quartzite veins or disseminated mineralization in various crystalline Ambatomainty schist facies. The sampling that we processed in the laboratory cuts perpendicularly from the migmatite amphibolite formation, that is to say that the magnetite feldo-quartzite is a recent formation which benefits from metamorphic fracturing. The presence of Fe, Mn, Ti, Cr, V, Zr, Y in the magnetite feldo-quartzite proves that the rise of acidic magmatic liquid which fuses the aureole of the surrounding rock, especially Gold in the amphibolite migmatite, makes the recent low-grade gold-bearing rock, because the gold in the migmatite is of low grade according to the result. Cr and V justify that the phenomenon in the area is volcanism which causes the rise of sterile magmatic liquid, but under the effect of the passage of liquid in the gold-bearing surrounding rock ensures low mineralization. It is a late magmatic type, generally linked as well with basic and ultrabasic rocks as with alkaline eruptive rocks.

Photos 14 : Pegmatite d'Ambatomainty Source : Auteur

CONCLUSION

To conclude, the Ambatomainty area no longer presents environmental coverage and is characterized by the phenomenon of lavakization.

The FIRE ASSAY processing confirms the presence of primary deposits in the study area which results from the digitization of the gold index map of the Alaotra region.

Mica schist is the known primary source of the secondary deposit.

Geologically, petrographic observation on the ground and geological literature justify that the study area is located in the Vohibory domain; it is characterized by predominantly calcic gneisses, quartzites and abundant cipolins. It forms in the Beforona group characterized by the presence of orthogneissified basic and ultrabasic rocks (amphibolitic gneisses). This metamorphic facies is part of the greenstone belt, otherwise the gold mineralized series favoring the epigenetic mineralization of Ambatomainty Gold. More precisely, this series is of the same type as the Maevatanana series, composed in its lower part of amphibolites, amphibole gneisses and supermicaceous gneisses. As for the upper part, reveals a less intense metamorphism marked by the presence of mica schists and chloritoschists.

The zone is formed by two magmatic stages: First magmatic assemblage M1 forms the protoliths or the original magmatic rocks (old formation) and M2 rise of magmatic liquid during the verticalization which formed the recent formation.

M1 brings the gold mineralization typically endogenous to the area due to the metamorphic phenomenon the current rock is formed. The magmatic liquid named L1 is gold-bearing during the formation of the original rock. It is likely that the magma liquids came from the same magma chamber, regardless of where they all solidified into gold.

Two types of cottages are present at Ambatomainty:

- primary as in mica schist, amphibolite migmatite; the gold grains are uniformly dispersed in the supporting rock during the crystallization of the original rock, the gold minerals unite to form a small gold bubble during magmatic differentiation (magmatic deposit of early crystallization),

- primary as in magnetite feldo-quartzite and in BIF or banded iron due to the volcano-sedimentary phenomenon in the green rock, which is considered as the main source of the secondary deposit in the sedimentary deposits.

Finally, this study proves the existence of a gold zone hidden for a long time in the Alaotra region.

A new gold map of Madagascar must be created, with a view to new exploration and/or prospecting guides, not only for the Ambatomainty sector but also for other sites in the Alaotra region.

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