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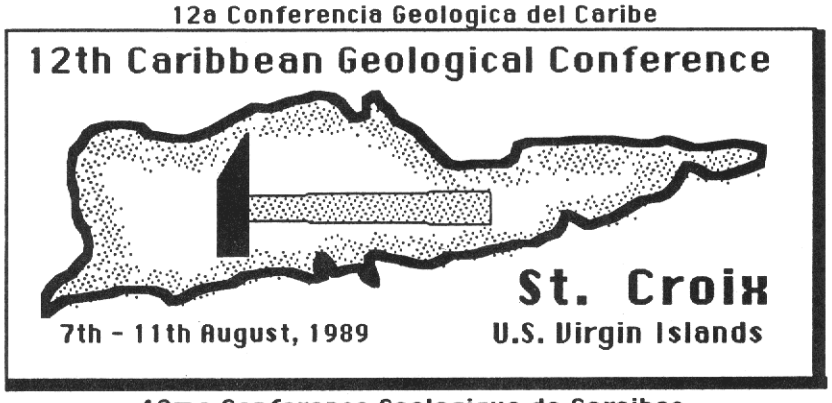

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GEOLOGICAL SETTING AND BASE AND PRECIOUS METAL DEPOSITS Of NORTHERN HAITI

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ABSTRACT

Northern Haiti is dominated by the Massif du Nord, a major anticlinal structure which represents the northwestern extension of Cordillera Central, the "backbone" of the Hispaniola segment of the Greater Antilles Cretaceous-Early Tertiary calc-alkaline volcanic arc. The core of the Massif du Nord is made of the extensive Loma de Cabrera batholith, partly enveloped by Pre-Albian ophiolite suite rocks, black shale units and Upper Cretaceous andesitic volcano-sedimentary series rocks. Its periphery is marked by a more or less continuous belt of Upper Cretaceous, intermediate to felsic volcano-sedimentary series (La Mine Series) bordered by the overlying Late Cretaceous-Paleocene Trois Riviéres flysch series and Tertiary limestones.

A spectrum of base and precious metal deposits in the Massif du Nord, is spatially and genetically related to two types of high-level magmatic systems, each characterized by distinct lithologies, alteration assemblages, mineral and geochemical associations. The first system is centered on quartz diorite porphyry stocks, high level periplutonic intrusions of the tonalite batholith, emplaced in Pre-Albian formations and in the deeper zones of the Upper Cretaceous andesitic volcanic pile. Mineral deposits related to this system comprise porphyry copper bearing stocks, limestone replacement deposits (Cu-Au-Ag skarns), copper-rich veins and auriferous quartz veins. Examples of these deposits are Douvray and Blondin with reserves of 200 million tonnes at 0.60% Cu and 50 million tonnes at 0.66% Cu respectively, Mémé former underground mine with potential resource of 3.5 million tonnes at 2% Cu, 2 g/t Au, 10 g/t Ag and Faille B gold deposit with drill indicated reserves of 520,000 tonnes grading 14.0 g/t Au.

The second major system sits higher in the stratigraphic sequence and represents epithermal polymetallic mineralization associated with stocks and domes of dacite hosted by the La Mine Upper Cretaceous volcano-sedimentary series. Mineralization exhibits volcano-tectonic fracture control and features strong Cu-Zn-Pb-Au-Ag barite associations and enrichment in Sb-Hg-As-Mo. The maximum gold and silver contents reported from this type of mineralization are 48.5 g/t Au and 640 g/t Ag. Mineralization is characterized by a large halo of advanced argillic alteration containing zones of chalcedony silica alteration, sulphide stockworks, massive powder-fine pyritization, barite veins, barite-sulphide lenses and stratabound replacements. Gold oxide deposits of this type of mineralization are Morne Bossa and Grand Bois with 2 million at 2.25 g/t Au and 4.5 million tonnes at 2.3 g/t Au respectively.

INTRODUCTION

Although Haiti has been celebrated since Columbus time for its historical workings of gold objects, it has had recorded only a few artisanal placer gold working in the Acul de Pins, Valliéres and Mont Organisé areas of northeast Haiti. Butterlin (1954) reported that approximately 2000 artisans were recovering 700-800 g of gold daily from Riviére de l'Acul de Pins. The only two significant metalliferous mines were the Reynolds bauxite mine in the Miragoane district of the Jacmel Peninsula in the south, and Sedren Mémé copper mine in the northewestern part of the country near Gonaives, which operated for a short time in the late 1960's. Increased interest in the mineral resource of Haiti started in 1975 and with various intensity has been continued through the present. With the discovery of important metallic mineral deposits made during the last ten years, northern Haiti is now recognized as a precious and base metal province, but until recently, its commercially extractable gold deposits have not gone into production.

The exploration models adopted and tested by the previous investigators in northern Haiti included among others Pueblo Viejo-type (Russel et al., 1976) and Kuroko-type (Ohashi, 1920) mineralization, but all efforts in locating economic deposits of this type of mineralization failed. Evidence obtained from studies performed by the United Nations-assisted projects throughout the Massif du Nord, as well as the discovery of the Faille B gold deposit by the United Nations Revolving Fund for Natural Resources Exploration (UNRFNRE) in the ultrabasic basement complex, necessitates the updating of previously reported information. Ideas on the Kuroko-type mineralization and the emphasized significance of the felsic volcano-sedimentary series in the localization of the most potential gold deposits in Haiti are subject to review. The importance of a genetic model for an effective and efficient exploration is well recognized by all exploration geologists. Exploration models are key to any exploration programme as they can help investigators focus

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on critical geological attributes and conserve funds that might otherwise be spent collecting data not critical to discovering an economic ore body.

The purpose of this paper is to provide a comprehensive review of the principal characteristics of all important deposit types of northern Haiti and to present a unified deposit model concept which hopefully would increase the effectiveness of exploration efforts and enhance the understanding of the metallogenesis and geological setting of Hispaniola. In the present review attention is focused on the epithermal mineralization system, which for first time is announced through this study and on the Faille B auriferous quartz vein system. The paper is mainly based on a mass of data generated by integrated exploration programmes carried out by the United Nations Development Programme and the Revolving Fund for Natural Resources Exploration during the last ten years and on field work conducted by this author between 1983 and 1988 in northern Haiti.

REGIONAL GEOLOGICAL SETTING

Haiti, the western third of Hispaniola, represents a segment of the Greater Antilles Cretaceous-Tertiary calc-alkaline volcanic arc formed at the convergent plate margins of North America and the Caribbean (Bowin 1975; Kesler 1978). Northern Haiti is dominated by the Massif du Nord which represents the northwestern extension of the Cordillera Central, the "backbone" of Hispaniola (Fig. 1). Massif du Nord displays an anticlinal structure of folded Mesozoic and Tertiary volcano-sedimentary series, intruded by the Loma de Cabrera tonalite batholith. Its most prominent structural feature is the NW-SE trending pattern of synclines and anticlines and the alignment of major fault zones in this direction. The synclines are usually marked by well-preserved volcano-sedimentary rocks, whereas the anticlines are almost exclusively intruded by the batholith. The principal faults of the Massif du Nord are the major Hispaniola Fault, Faille Fault Zone and Cerca Caraval-Monpin Crochu Fault, all striking NW-SE. The Hispaniola Fault bounds the Massif du Nord on the north and is inferred to extend from the Dominican Republic through Ouanaminth to Fort Liberté. The Faille B Fault Zone, up to 1.2 km wide and 40 km long, occurs along the central axis of the Massif du Nord from Trou du Nord to Mont Organisé located close to the border of the Dominican Republic. The Cerca Caraval-Monpin Crochu Fault Zone borders the southeastern part of the Massif du Nord on the south and apparently extends to Padre las Casas in the Dominican Republic (Fig. 2).

The geological features and history of the Massif du Nord were comprehensively reviewed by Woodring et al. (1924) and Butterlin (1954). In broad terms the geological setting and base and precious metal potential of the Massif du Nord may be understood better in the context of a simplified division shown in Figures 3 and 4. The earliest known rocks in the Massif du Nord, apart from the schists of Ile de la Tortue (uncertain age) are represented by the Jurassic Morne Cabrit Series of ophiolites, inferred to correspond to the Duarte Formation in the Dominican Republic, where K-Ar age dating indicated metamorphism of 125 Ma. The Morne Cabrit ophiolitic suite consists of peridotites, serpentinites,

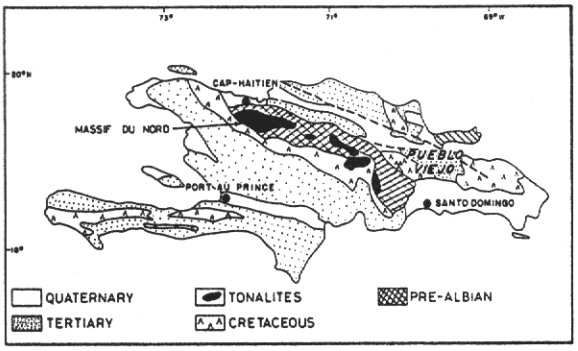

Figure 1. Simplified geological map showing major features of Hispaniola, from Donovan and Louca (1989).

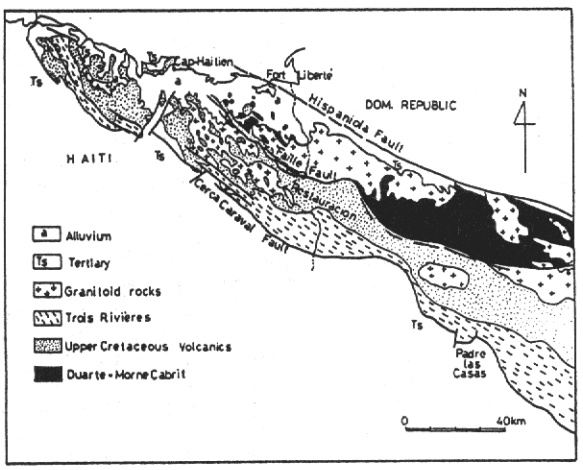

Figure 2. Generalized geological map of the Massif du Nord and Cordillera Central. Geology of the Cordillera modified after Lewis (1989).

harzburgites and dunite at its base, overlain by pyroxenites, hornblendites and gabbros. Dolerites, basalts and locally basic tuff and radiolarites form the uppermost part of the sequence. The rocks underwent metamorphism varying from greenschist to epidote-amphibolite facies and in hydrothermally altered zones are transformed to tremolite-chlorite schists, talc schist and sericite (fuchsite) schists. Contact metamorphism has been superimposed on the regional effects at the contacts with the tonalite intrusions, resulting into amphibolites. The most frequent occurrences of the Morne Cabrit ophiolites are confined to the eastern part of the Massif du Nord, and their present disposition is in the form of discrete roof pendants and linear septa of the batholith and tectonic slices associated with major fault zones.

The Morne Cabrit Series is overlain by the Lower Cretaceous Perches Series, consisting mainly of carbonaceous shales and felsic

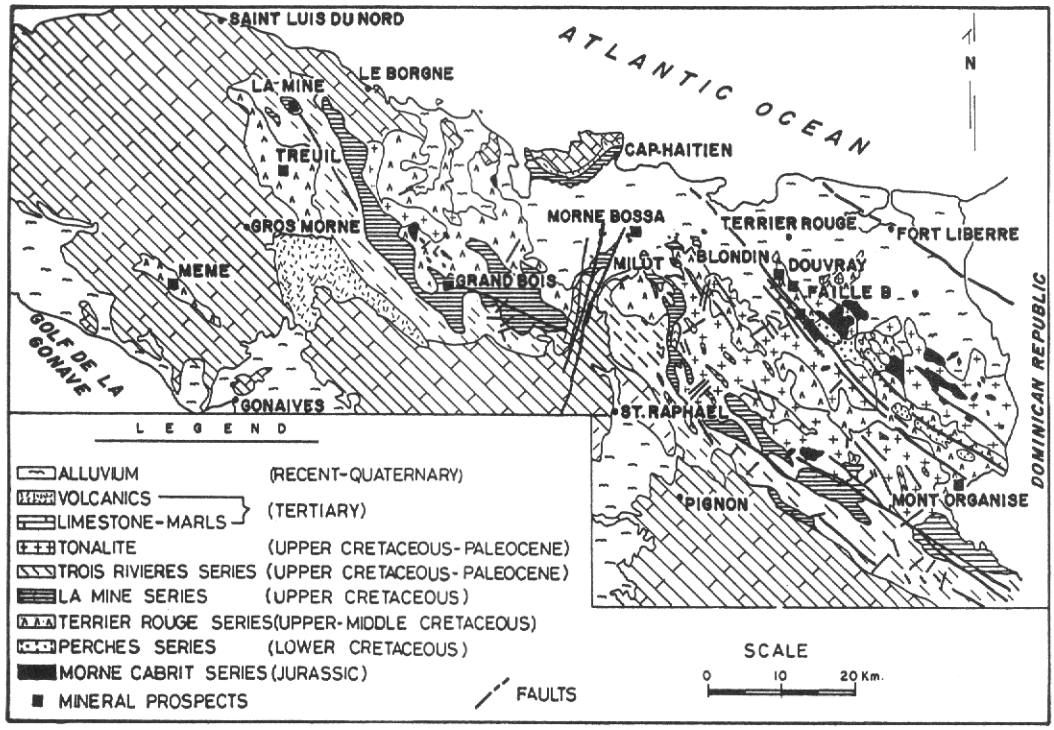

Figure 3. Geological map of the Massif du Nord. Modified after UNDP maps (1977).

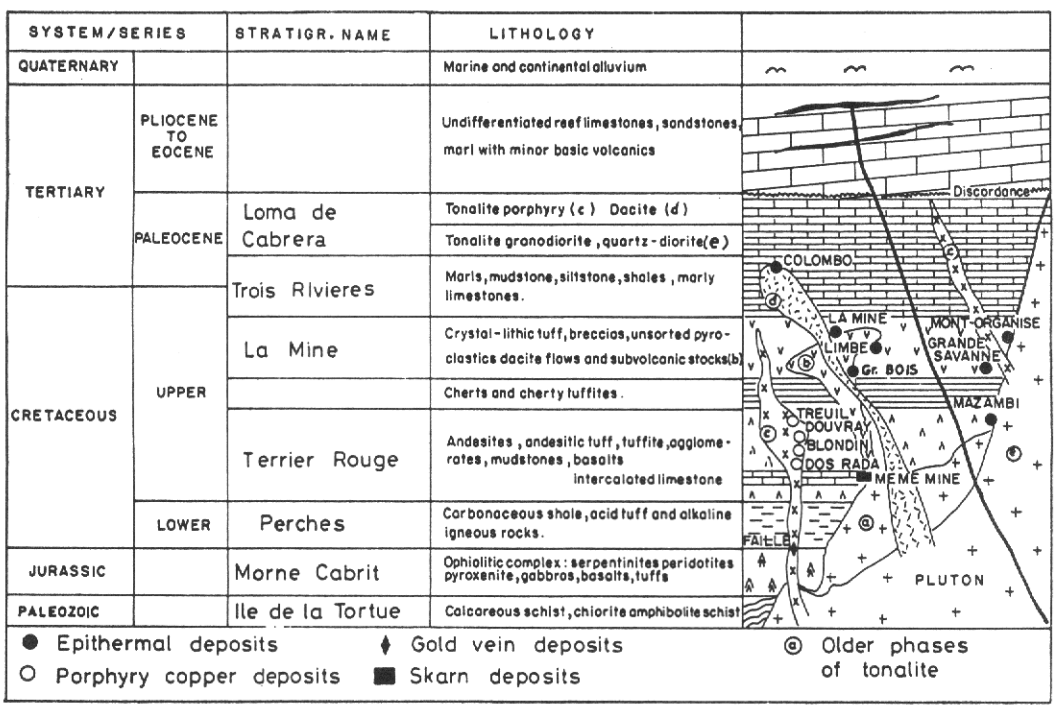

Figure 4. Generalized lithostratigraphic column and mineralization systems of the Massif du Nord (Louca 1988).

volcaniclastics. In the Faille B area (Grand Bassin) important lithologies include intercalated cherts and well laminated barite, ranging from few centimeters to two meters in thickness. Perches Series has limited distribution in the Massif du Nord and is preserved as thin patchy outliers over the ophiolite complex and as tectonic slices and microbreccias. The distribution of the individual lithostratigraphic members of this unit is very irregular and there is no evidence of a completely developed succession. Nicolini (1977) considered the Perches Series to be an equivalent of the Los Ranchos Formation, which is the host of the Pueblo Viejo gold deposit in the Dominican Republic.

Upper Cretaceous volcanism in the Massif du Nord, largely basaltic and andesitic at the beginning, was succeeded by dacites. The volcanic activity was interspersed with sedimentation and a thick volcano-sedimentary pile was constructed. The basalto-andesitic member of this volcano-sedimentary pile was named the Terrier Rouge Series by previous workers (Nicolini, 1977) and the upper felsic member was termed the La Mine Series by this author, who also considers it to be equivalent to the upper part of the Tireo Formation in the Dominican Republic (Louca, 1985 and 1987).

The Terrier Rouge Series with a total thickness near one kilometer, is very widespread in the Massif du Nord and in general forms huge septa and segments of synclines in the Loma Cabrera batholith. It consists of green and red vitric tuffs, tuffites, agglomerates, basalt and andesite flows, with interstratified mudstones, polymict conglomerates and limestones. The conglomerates represent both marine and subaerial facies and include hematitic and multicolored varieties consisting of andesitic and more basic material. The andesite flows vary in composition and texture between various outcrops. Fine-grained homogeneous andesite showing doleritic textures and amygdaloidal andesite and ophitic textures are the most frequent types. Mineralogically, the flows consist of andesine, augite, amphibole, orthorombic pyroxene and quartz. The Terrier Rouge rocks have undergone greenschist facies metamorphism characterized by the following mineral assemblage: albite-quartz-chlorite-epidote (actinolite)-calcite. In proximity to the batholith the rocks are traversed by a network of quartz-epidote veinlets and in direct contact with the batholith they have been transformed into hornfels. The Terrier Rouge Series correlates with the Lower Tireo Group rocks in the Dominican Republic, consisting of a sequence of red and green vitroclastic tuffs, andesite flows and agglomerates with intercalated mudstones, siltstones and limestones (Lewis et al., 1989). The paleontological determinations cited by Lewis et al. (1989) on the Lower Tireo Group rocks suggest a Turonian to early Senonian age for the main volcanism.

Upward passage from the Terrier Rouge Series to the La Mine Series varies from sharp to gradational and in a few areas is marked by a horizon of black cherts and cherty tuffites which vary from a few meters to 50 m in thickness. La Mine Series has a total estimated thickness of 500 meters and forms a more or less continuous belt confined to the outer periphery of the Massif du Nord. The belt consists of coalesced products of several discrete centers of Upper Cretaceous dacite volcanism and its principal components are tuff breccias, crystal-lithic tuffs, dacite flows and stocks, unsorted pyroclastics, laharic deposits and locally ignimbrites. In the La Mine area a porphyritic dacite (Morne Petriac) constitutes the base of the succession, overlain by a coarse monomict lahar breccia of this parent rock. The breccia is overlain by unsorted pyroclastics which are in turn overlain by crystal-vitric-lithic tuffs, grading upwards into the Trois Riviéres flysch series. Pyroxene dacite stocks with associated pyritization cut through this sequence. Variations displayed in the Camp Coq (Grand Bois) area include the presence of quartz-eye crystal tuff and ignimbrites. Tuffites and cherts are locally interbedded in the crystal tuffs. No useful fossil data are available to constrain the age of the La Mine Series, nor its equivalent Upper Tireo volcanism in the Dominican Republic. K/Ar age data from Camp Coq suggest that the main volcanism in the Massif du Nord did not begin before early Santonian. In the Restauracion area (Dominican Republic) the Upper Tireo volcanism is dated at 81.2 + 0.8 Ma by Ar^{40}/Ar^{39} on a hornblende separate (Jimenez and Lewis, in press).

The Trois Riviéres Series (Late Cretaceous-Paleocene) overlies conformably the La Mine Series and marks the beginning of prevailing marine conditions in the Tertiary. The series mainly represents turbiditic sediments consisting of mudstones, marls, limestones and locally greywackes. Thin-bedded ferruginous limestones and intercalated tuffites are confined to the base of this sequence. The maximum thickness of the Trois Riviéres Series exceeds 500 m.

The Upper Cretaceous-Paleocene period was marked by the most important geological event in the evolution of the Massif du Nord, the emplacement of the Loma de Cabrera batholith and the associated high-level periplutonic stocks. The batholith was emplaced not only into the Morne Cabrit Series but also into the Upper Cretaceous volcaniclastics and the lower members of the Trois Riviéres Series. A number of K-Ar age determinations have been made on the tonalites of Hispaniola (Bowin, 1966, Kesler and Sutter, 1977) and the age of the batholith has been examined using Rb/Sr isotope methods (Feigenson, 1978). The available data indicate that the tonalites were emplaced as magmas between 90 and 48 million years before present (Lewis, 1982). In the Massif du Nord, hornblende tonalite with small amounts of biotite is the dominant rock type and locally may grade to quartz diorite and quartz monzonite, in the Streickeisen (1974) classification. It varies texturally from medium to coarse grained and from equigranular to porphyritic types. In general it is quite inhomogeneous containing high amounts of quartz-epidote stringers and partially assimilated xenoliths of older rocks and resultant, hybrid products. As a result of the regional metamorphism the tonalite has undergone strong chloritization and epidotization. Clear intrusive deformation effects are seen in some

areas where the country rocks were raised to amphibolites whereas in others, passive emplacement of tonalite into host-rocks is apparent. Occurrences of small porphyry stocks of similar composition as the batholith but with associated copper and gold mineralization are abundant in the Massif du Nord and are described further in this study.

From the early Eocene onward calc-alkaline magmatism declined and was replaced by widespread limestone and marl sedimentation. Minor isolated acid and basaltic volcanism occurred in the Tertiary.

METALLOGENIC SETTING

Metallogenically, Massif du Nord exhibits many similarities to the Dominican Republic and to the other Caribbean volcanic arcs but it has also its own peculiarities in both style and time of deposition of mineralization. Temporal correspondence is seen with the Dominican Republic in the development of porphyry copper deposits and epithermal-polymetallic deposits, during the latest phases of the Upper Cretaceous magmatism and the occurrence of auriferous quartz veins in ultrabasic and basic rocks. Differences between the metallogenic evolution of these two parts of Hispaniola include the absence of volcanogenic massive sulphides and Pueblo Viejo-type mineralization in the Massif du Nord. These peculiarities of the Massif du Nord are related directly to its tectonic evolution which includes among others the absence of the Pre-Albian Maimon Formation, host of volcanogenic massive sulphides, and very limited occurrence of the Lower Cretaceous Los Ranchos Formation, host of Pueblo-type epithermal mineralization in the Dominican Republic. The absence or weak development of these formations was probably related to the lack of significant fragmentation of the Massif du Nord during the Lower Cretaceous subduction process.

A spectrum of base and precious metal deposits in the Massif du Nord is spatially and genetically related to two distinct types of high level Upper Cretaceous magmatic systems: the lower consists of quartz diorite and tonalite stocks with associated porphyry copper mineralization and the upper of dacitic stocks and domes with associated epithermal-polymetallic mineralization hosted in the La Mine Series (Fig. 4). The only authentic occurrences of syngenetic stratabound precious metal mineralization in the Massif du Nord are thinly laminated barite-chert seams which are found locally in the Lower Cretaceous Series. The polymetallic mineralization associated with the La Mine Series was regarded by previous exploration groups as submarine volcanogenic and was compared to a Kuroko-style mineralization (Société Minière d'Haiti, 1977 and Société Franco-Haitienne des Mines, 1980). Our recent work has shown no evidence supporting this genetic model.

DISTRIBUTION AND DESCRIPTION OF BASE-PRECIOUS METAL MINERALIZATION

This section of the study attempts to classify the various styles of primary base and precious metal mineralization and describes their principal characteristics and geological setting. In the following discussion, base and precious metal deposits and occurrences have been divided into the following major groups: syngenetic stratabound mineralization in the Lower Cretaceous Perches Series, deposits associated with Upper Cretaceous granitoid-porphyry stocks and polymetallic-epithermal mineralization associated with the Upper Cretaceous La Mine Series. It should be emphasized that all significant mineral deposits and occurrences in the Massif du Nord can be included within these categories. The classification scheme adopted in this study is based on both lithological and structural criteria, as well as on alteration types, geochemical and mineral associations.

Stratabound Base-Precious Metal Mineralization

This type of syngenetic mineralization has been recorded only in one locality in the Faille B area of the Grand Bassin mineral district. It is composed of thinly laminated barite seams, varying in thickness from a few centimeters to 2 m, which occur in the Perches Series covering an area of 150 x 100 m. The barite beds occur in metatuffs and metasediments of various stratigraphic horizons and grade laterally to recrystallized grey cherts which resemble jasperoids. Fine-grained pyrite with delicate layering occurs as thin interlayers up to 0.5 m thick, in metatuffs. The barite is variegated with alternating brown, tan, grey, light grey and dark grey aphanitic laminae. The laminations result from fine hematite, graphite and tiny interlayers of chert and carbonate. The barite contains up to 5 g/t Au, 40 g/t Ag, 0.28% Pb and 0.16% Zn.

Brecciation and recrystallization which occurred during folding, intense faulting and intrusion of tonalitic stocks modify and obscure the original character of this type of mineralization. The possibility of an affinity with the Carlin model was initially considered but later rejected on the basis of petrographic and mineragraphic work which indicated that the lamination of barite and sulphides is sedimentary. (Dressler, 1985 and Harris, 1986). The writer interprets the mineralization as having submarine hot spring origin.

Mineralization Associated with Granitoid-Porphyry Stocks

Copper mineralization with appreciable amounts of gold and silver in the Massif du Nord, is centered on small, shallow granitoid intrusives that range from hornblende microtonalites and quartz diorites to less common granodiorites and quartz monzonites. They are mainly fine-grained and porphyritic but locally are heterogeneous displaying variations in texture, grain size and modal composition. Leucocratic and mafic varieties and hybrid rocks occur locally. The intrusives vary in surface area from a few tenths of a square kilometer to 2 square kilometers and are often elongated in a northwest-southeast direction, representing forceful injections along pre-existing fault zones. Discontinuous sets of both elongated and oval-shaped stocks occur along well defined

northwest-southeast lineaments, particularly along the central axis of the Massif du Nord. According to the mode of mineral occurrence and composition, the deposits associated with these shallow-level stocks have been sub-divided into limestone replacements, porphyry copper, copper veins and auriferous quartz-sulphide veins.

Limestone Replacement Deposits

The limestone replacement deposits are found in the Terre Neuve Mountains, on the southwestern flanks of the Massif du Nord, where the Cretaceous volcanics are exposed in a narrow window through the Eocene limestones. The area exhibits a complex structural history characterized by northwest-southeast trending fold axes and fault traces. The volcanic rocks show an apparent compositional gradation from andesite to dacite, contain intercalations of siltstones and limestones and they are intruded by the Terre Neuve stock. The stock varies in composition from quartz monzonite to quartz diorite and forms three small elongate bodies along the axis of a broken anticline. Kesler (1968) cited an age of 66 Ma from this stock. Mineral deposits associated with the Terre Neuve stock include the dormant Mémé copper mine and three other prospects of which Causseus is the most developed (Fig. 5).

Base and precious metal mineralization has been emplaced in both stock and altered volcanics but mostly in skarns developed in blocks of recrystallized limestone and marble that were tapped into the stock during the intrusion. The skarn-intrusion contacts are sharp but show mineral zonations and two gradational types of skarns. The skarns contain garnet, epidote, chlorite diopside, wollastonite, tremolite, magnetite and hematite. Sulphides include pyrite, chalcopyrite, bornite, chalcocite, digenite and locally molybdenite. The sulphides occur as disseminations, irregular massive replacements, interstitials and veinlets in the skarn, and as disseminations and parallel veinlets banded with quartz, in the intrusive. The deposition of metallic minerals began during the waning stages of skarn formation and continued after the cessation of skarn mineral deposition (Kesler, 1968). The skarn-sulphide paragenesis, as well as other characteristics clearly point to the transitional nature of this mineralization and its intriguing link between contact - localized ore and porphyry copper ore.

Based on drilling and underground development work the original ore reserves at Mémé, are estimated to be 3.5 million tonnes grading 2% copper, 2 g/t gold and 15 g/t silver. Certain portions of the mineralized skarns contain up to 23 g/t gold. To date the indicated resources in the Terre Neuve mineral district, computed from data on Mémé Mine and the other prospects, are 6.0 million tonnes with ore grades similar to those of Mémé Mine. Mémé was brought into production by SEDREN S.A. in 1960 and operated until December 1971. Approximately 2 million tonnes of ore at 2% Cu was mined from underground workings. The mine appears to have closed in early 1972, when it failed to meet a concentrate shipment during a period of low copper prices and the Bank d'Haiti assumed all assets. The geology and mineralization at Mémé Mine have been described and illustrated in a number of publications including those by Kesler (1966, 1968).

Porphyry Copper Deposits

Porphyry copper deposits and occurrences are widespread in the Massif du Nord and they are related to small, irregular, porphyritic hornblende tonalite and quartz diorite stocks, that are emplaced in the Terrier Rouge or earlier metabasaltic rocks. In the western part of the Massif du Nord they occur as isolated stocks cutting volcanic terrain and in the east are clustered close to the border of the Loma de Cabrera batholith. The latter intrusive environment is presumably indicative of a deeper regional erosion level.

The northern Haitian deposits belong to a distinct porphyry copper deposit class, lacking the typical concentric alteration-mineralization zoning and extensive feldspar-destructive alteration. The deposits are typified by propylitic alteration characterized by epidote, chlorite, calcite, quartz and albite with an intimate association with sulphides. The stocks and their host rocks are both altered and mineralized in parts and it is difficult to formulate a general rule governing sulphide distribution. The dominant sulphides are chalcopyrite, pyrite and bornite occurring as fine disseminations, small blebs, patches, veinlets, either alone or with quartz and/or epidote and calcite. The amount of chalcopyrite and pyrite as well as their ratio vary considerably from deposit to deposit. Pyrite and chalcopyrite contents range from 0-10% and 1-5% respectively. Geochemical associations include Zn, Mo, Au and Ag.

Deposits of this sub-group, considered to possess the greatest potential, are Douvray and Blondin, located 40 km southeastward of Cap-Haitien (Fig. 6). At Douvray the potential exists for some 200 million tonnes of 0.6% copper ore and at Blondin the drill-indicated resource is on the order of 50 million tonnes averaging about 0.66% Cu. Systematic assaying for gold has not been done but to date the highest average grades of these deposits are about 0.30 g/t Au. Quartz veins carrying up to 9.0 g/t Au and 42 g/t Ag occur locally at Blondin. Oxidation is shallow, ranging from 5 to 20 m and supergene sulphide mineralization is limited.

Other occurrences of porhyry copper mineralization in the Grand Bassin area include Dos Rada (Louca, 1988), and Philippe (Fig. 6). Copper-bearing porphyritic tonalite and quartz diorite intrusives of much smaller dimensions such as dykes and elongated narrow bodies occur in several other locations in the Massif du Nord. Within one of these stocks is the Treuil prospect located due north of Gros Morne town (Fig. 3). Treuil prospect is found within a quartz diorite stock with associated rich supergene sulphides in irregular fracture fillings up to 2.0 m in width, carrying more than 10% Cu and several ounces per tonne silver. Host rock lithologies include andesitic and basaltic tuffs.

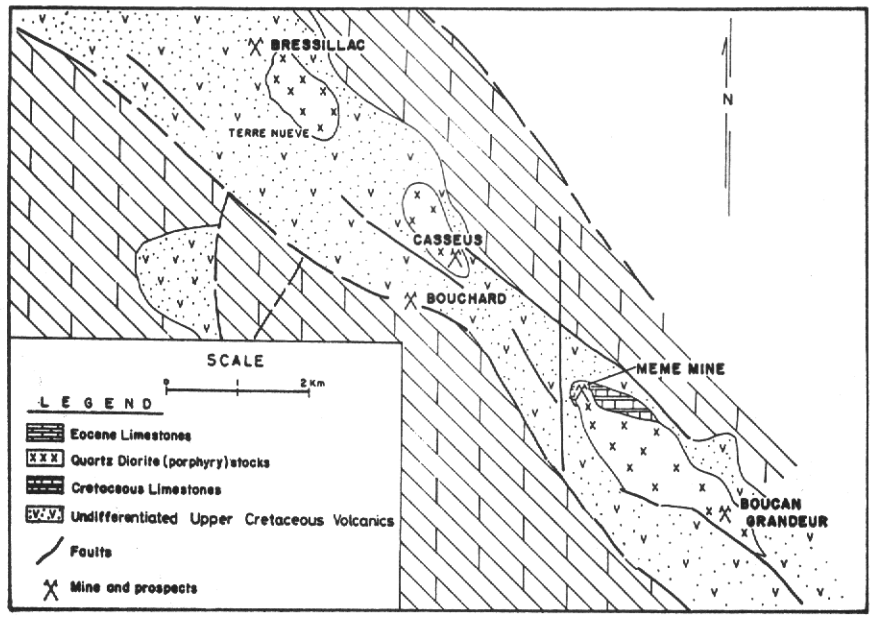

Figure 5. Simplified geological map of Terre Neuve Mountains. Modified after Kesler (1968).

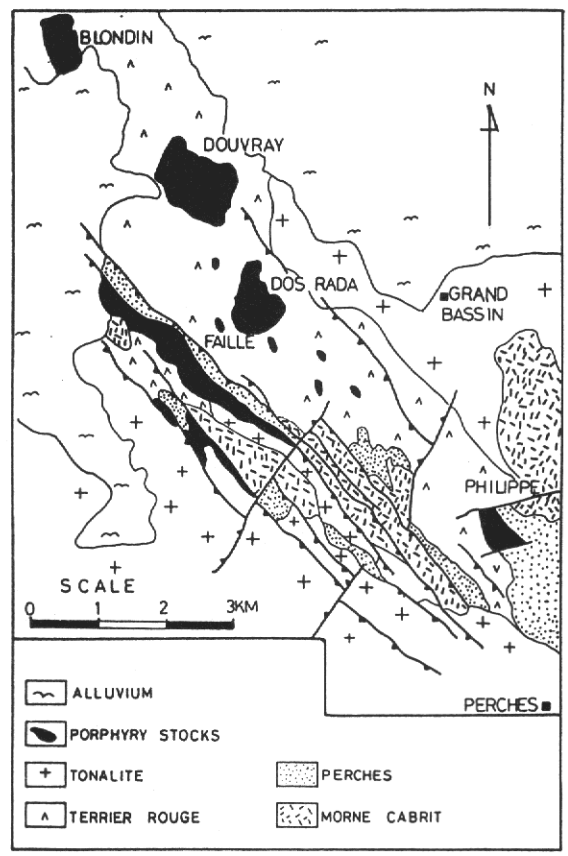

Figure 6. Geological map of the Grand Bassin area. Reduced from 1:50,000 map (Louca, 1988).

The Mont Organisé prospect located in northeastern Haiti, along the border with the Dominican Republic, although not yet thoroughly defined, can be provisionally classified as a porphyry type deposit (Fig. 3). Alteration and sulphide mineralization is apparently confined to the contact zone between the Upper Cretaceous volcano-sedimentary series and a porphyritic tonalite. Disseminated sulphides are mainly pyrite whereas copper and gold mineralization is more sporadic and follows the fracture systems.

Vein Copper Mineralization

Copper-bearing veins and shear zones represent the second main type of widespread copper mineralization in the Massif du Nord. They are found mainly in the lower stratigraphic units (Morne Cabrit and Terrier Rouge Series) and they occur within and are marginal to porphyry copper systems, as well as in fault zones without obvious relation to copper-bearing stocks.

The veins are represented by several varieties of fissure veins such as single fractures, sheeted zones of closely spaced joints and veinlets, varying in width from a few centimeters to a few meters. They range from a few tens of meters to a few hundreds of meters in length. The main copper mineral is chalcopyrite and it is locally accompanied by minor bornite and pyrite. Gangue minerals include quartz, chlorite and calcite occurring in various proportions with sulphides. The oxidized zone of the veins is characterized by copper carbonates, pitch limonite and goethite. This class of veins shows strong silver enrichment, up to 62 g/t but in most cases their gold content is less than 0.20 g/t. The deposits are generally small and vary from 15,000 tonnes to 50,000 tonnes at 2% Cu.

Auriferous Quartz-sulphide Veins

This type of gold mineralization is associated with a microtonalite stock hosted in the Morne Cabrit ophiolites and its major occurrence is Faille B gold deposit located in the Grand Bassin mineral district (Fig. 6). Douvray and Blondin porphyry copper deposits are located only 2 km north-northeast and 4 km north of Faille B. The deposit occupies the eastern part of the Faille Fault Zone, marked by a series of NW-SE faults which bring various lithostratigraphic units into juxtaposition as tectonic sheet-like bodies, aligned parallel to the regional trend (Fig. 7). The most characteristic geological feature of Faille B is the elongate and tabular wedge-like body of hornblende microtonalite, emplaced along a major shear zone in ophiolites and other Lower Cretaceous rocks. The microtonalite is more than 2 km long and varies in width from 250 m on the northwest and 25 m on the southeast. It has a relatively fine-grained porphyritic texture but is locally quite heterogeneous, with variations in texture and grain size. It is generally characterized by strong chloritization, moderate propylitization and zones of sericitic alteration and contains tiny stringers and impregnations of pyrite and chalcopyrite (Louca, 1988, Donovan and Louca, 1989).

The microtonalite and its wall rocks, particularly the Morne Cabrit ophiolites are the principal hosts of most of the auriferous quartz veins. The Morne Cabrit ophiolites consist mainly of sheared rocks mapped collectively as "metabasites". They include meta-peridotites, meta-gabbros, meta-basalts, actinolite-chlorite schists and tremolite-chlorite schists. Veins in "metabasites" at the surface have been found to cut the microtonalite at depth in some cases.

The veins range from simple to exceedingly complex systems, such as multiple lenticular veinlets, sheeted banded veins and systems of quartz veinlets. Most of the veins strike NW-SE, comformably with the structural grain of the area and have westerly dips ranging from 40 to 65 degrees. Steeper veins with opposite dips, however, also occur and in some cases vein material passes with many changes of dip and strike from one fracture to the other. The simple massive veins, or the veinlets which constitute the sheeted veins, vary in width from a few centimeters to one meter, while the vein systems reach up to 3 m in width. There are at least five principal quartz vein systems in the microtonalite. Although the quartz veins occur over a distance of more than 2 km, individual veins can usually be traced from trench to trench for only 50 to 70 m before pinching out (Fig. 8).

Quartz is the principal gangue mineral, occurring as several distinct textural types, of which a rather fine-grained variety predominates. It exhibits heterogeneous grain variations, fragmentation and incipient brecciation and ranges in colour from grey to light grey and glassy, with delicate chlorite and sulphide banding. Chlorite is an abundant gangue mineral and is widely distributed throughout the vein selveges and as a vein mineral replaced by quartz or vice versa. Barite and calcite occur locally in some of the quartz veins. Pyrite is the most abundant sulphide, generally comprising 3 to 15% of the vein. Chalcopyrite and sphalerite locally form concentrations up to 5% and 10% respectively.

Gold occurs as the native metal and exists in the primary mineralization mainly as grains from 2 to 50 microns in diameter. In the oxidized veins it is rarely visible to the naked eye. The distribution and size of gold grains determined from microphotographs suggests that the gold is less than minus 200-mesh in size and much would pass through minus 400-mesh screen. Gold shows diverse associations: specks within chlorite wisps and quartz, on contacts of sulphide grains, and less frequently as inclusions in microfractures in pyrite.

The distribution of gold in quartz veins along strike and dip is erratic, as demonstrated by both trenching and drilling (Fig. 9). The gold within a sheeted or multiple vein section tends to be confined to a single vein component and is often concentrated in the chloritic walls of the veins. The amount of chalcopyrite generally increases sympathetically with gold grades, but the reverse is not always true, at least according to the assays, although this

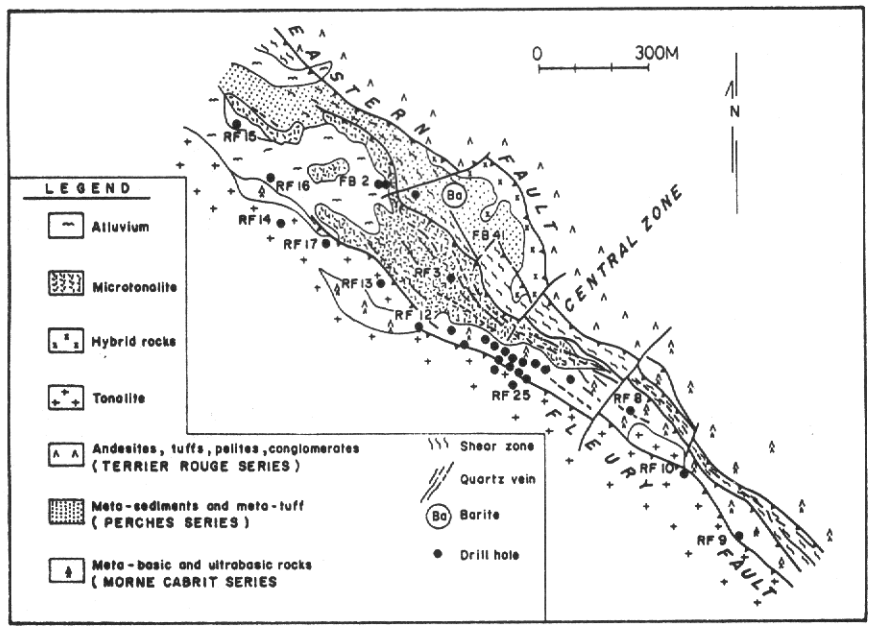

Figure 7. Geological map of Faille B area. Reduced from 1:2,000 maps (Louca 1985-1988).

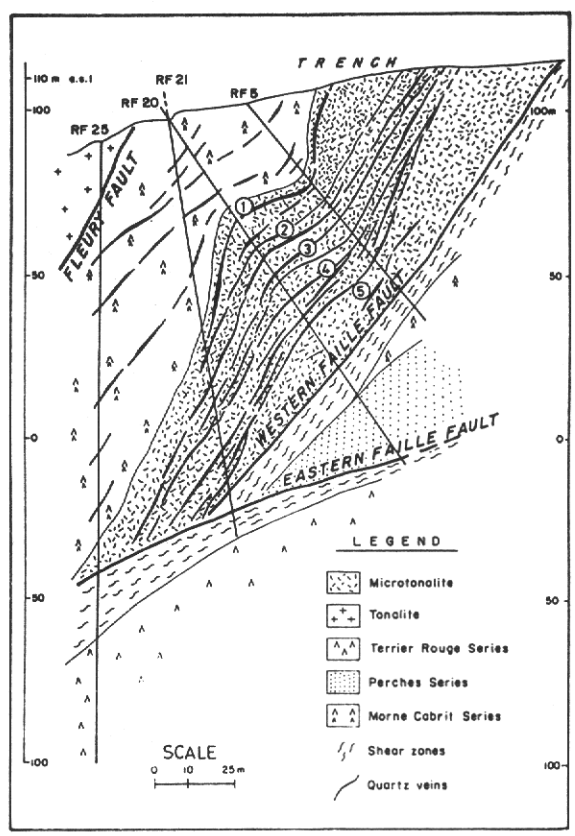

Figure 8. Cross-section of the Central Zone of Faille B gold deposit (Louca 1985-1988).

effect may be due to the spotty distribution of the gold particles. Gold contents in quartz veins from trenches range from traces to 230 g/t. Gold values persist with depth and only in a few cases was secondary enrichment of gold suggested in the oxidized zone, which varies from 15 to 25 m depth. Gold values up to 200 g/t were encountered at depths of 120 m in the primary zone. The auriferous quartz vein mineralization shows enrichment of Ag, Cu, and Te. The following elements appear to be somewhat enhanced: As, Sb, and F.

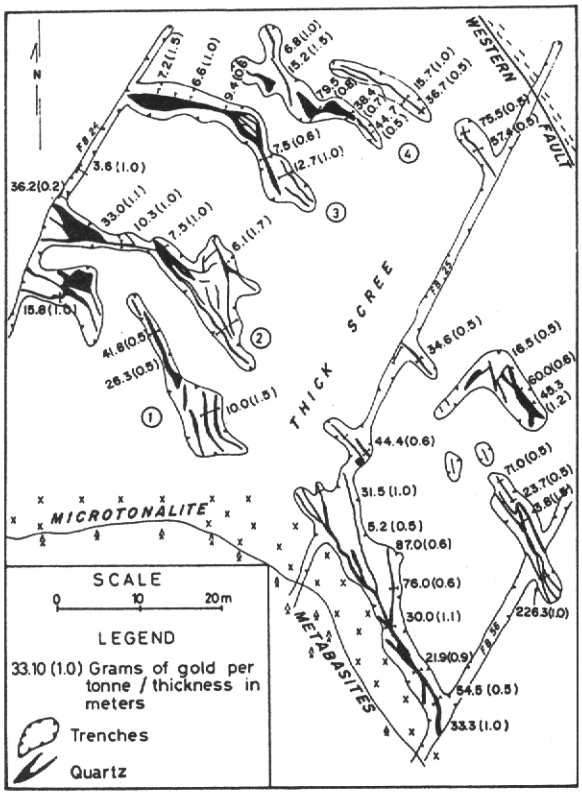

Figure 9. Distribution of gold and quartz veins in the Central Zone of Faille B (Louca 1985-1988).

Positive gold mineralization was encountered by drilling and trenching over a strike length of 1.8 km but the wide spaced drilling does not allow reliable calculation of grade and tonnage for the entire belt. Estimates of grade and tonnage were made in the Central Zone of Faille B (300 m strike length) where there is a higher concentration of gold and frequency of drillholes. Drill-indicated tonnages are 520,000 tonnes at 14.0 g/t Au.

The textural and geochemical characteristics of the Faille B auriferous quartz veins are similar to veins associated with dioritic intrusions in an active tectonic environment. The syntectonic emplacement of the quartz vein material is evidenced by textures indicative of plastic deformation, cataclastic textures and the development and closing of open spaces for vein formation by tectonic movement. Textural relationships of mineralized quartz veins suggest overlapping paragenesis of gold and vein constituents and two phases of gold deposition. The earlier phase of gold introduction is represented by the small inclusions of gold in pyrite and the later phase is associated with chalcopyrite and chlorite wisps and quartz. The stronger development of quartz veins within the stock is thought to be due to the relatively brittle character of this intrusive compared to the ductile nature of the sheared metabasites and metasediments.

Epithermal-Polymetallic Mineralization

General Statement

Oxidized ore of the epithermal-polymetallic mineralization is an important part of the mineral resource endowment of the country. So far, two such deposits have been discovered and thoroughly evaluated with respect to their tonnage, grades and gold leacheability characteristics. These are Grand Bois and Morne Bossa (Fig. 3), containing 4.5 million tonnes of extractable oxide ore with 2.3 g/t Au and 2.0 million tonnes with 2.25 g/t Au respectively.

Although the association of this type of mineralization with the Upper Cretaceous La Mine Series is well known in Haiti, its volcanogenic setting and characteristics are not available in the literature and its specific deposit type has not been classified until now. The superficial resemblance of local occurrences of black massive sphalerite with the black Kuroko-type ores, the presence of massive pyrite and barite, as well as the close association of the mineralization with the relatively felsic volcano-sedimentary series led previous investigators to relate this mineralization to a Kuroko model. Both Société Minière d'Haiti (S.M.H., 1977) and Société Franco-Haitienne des Mines (S.F.H.M., 1980) engaged in the exploration of massive sulphides in the Camp Coq-Limbe area, and mapped and interpreted all sulphide stockwork zones as exhalite horizons and divided the La Mine Series into pre- and post-mineralization units. All undeformed massive barite-sulphide mineralization was interpreted as being syngenetic ore and the fragmented and cataclased massive mineralization as distal "conglomeratic" Kuroko-type ore.

Our studies throughout the La Mine volcanic belt, from the Dominican border in the southeast, to the Colombo prospect 110 km to the northwest, have shown that the mineralization does not fit the definitions of Kuroko-type or any other sub-type of stratabound-syngenetic sulphide mineralization. Extensive detailed geological mapping supported by petrological and mineragraphic studies, and geochemical and geophysical data, support the interpretation that the north-Haitian mineralization belongs to a unique replacement-deposit type. The present study favours a shallow epithermal origin, which is based on diagnostic features in the nature of both host volcanics and sulphide-barite mineralization, as well as in the overall structural setting and geochemical and mineralogical association of the deposits. Epithermal mineralization of similar characteristics and age to the mineralization of

northern Haiti, has been described by Amarante et al. (1989), in the Upper Tireo Group rocks of the Restauracion area in the Dominican Republic. This section will briefly describe the geological, mineralogical and geochemical characteristics of this north-Haitian mineralization, so that it may be easily related to other epithermal, precious-metal deposit types.

Depositional Environment of Host Rocks

The mineralized portions of the La Mine Series consist of multicyclic volcanic accumulations, predominantly dacitic in composition, which grade laterally and vertically from subaerial tuffs and pyroclastics to submarine volcanic sediments. A subaerial depositional environment prevails at the base of the volcanic pile and in some areas also at the upper part of the sequence. Purely sedimentary components include interbeds of siltstones, greywackes and cherts varying in thickness from one meter to a few meters. The maximum thickness attained by the volcanic pile at La Mine and Grand Bois area is 500 m and 400 m respectively.

Typically, the first and lowermost portions of the sequence are tuff breccias, and heterolithologic lahars, followed upwards by flow breccias, unsorted fine pyroclastics and dacite flows. The uppermost portion of the pile contains abundant massive or bedded lithic-crystal tuffs and ignimbrites. A characteristic feature of the La Mine Series is that it is intruded by subvolcanic stocks and dome-like protrusions of quartz porphyry, rhyodacite and porphyritic quartz-hornblende dacite. In many areas these shallow intrusives form local extrusive accumulations and result in both intrusive and extrusive equivalents of the same lithology.

Distribution of Mineralization

This type of sulphide mineralization has the tendency to occur in swarms or clusters in structurally complex areas of which the best known are La Mine-Colombo area, Limbe-Camp Coq area, Milot-Grande Riviére area, and Bois Laurence-Grande Savane area. The two oxide gold deposits mentioned above, Grand Bois and Morne Bossa, occur in the Limbe-Camp Coq and Milot-Grande Riviére areas respectively.

Unlike the various forms of exhalite deposits, including stratiform massive sulphides which occur within a fairly narrow stratigraphic interval or even along a single horizon, the north-Haitian sulphide mineralization has a demonstrable structural control and cross-cuts all distinct lithostratigraphic members of the La Mine Series (Fig. 10). The structural control is seen as a concentration of high angle faults and fractures, fault intersections and intersections of faults with relatively permeable or reactive rocks. The general disposition of the mineralization is in the form of linear fault and fracture zones up to 3 km in length, whose orientation is partly oblique or is conformable with the regional structural grain. The mineralized zones are usually bound by faults and their overall position is discordant to the orientation of the volcaniclastic series rocks. Stratiform replacements are very restricted and present as thin discontinuous zones of jasperoids and small lenses of barite with sulphides. Also,

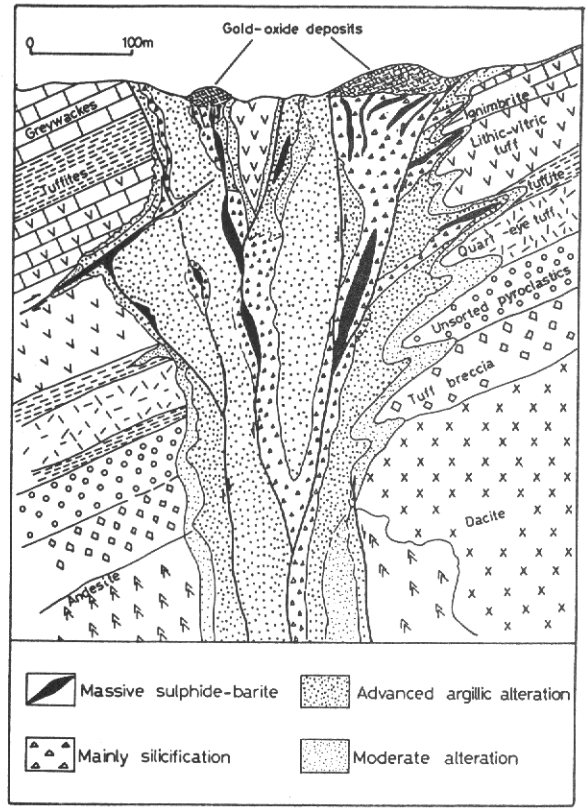

Figure 10. Schematic cross-section of the epithermal mineralization system in the La Mine Series (Louca 1987).

there is a striking spatial association between the mineralization and the dacite stocks and domes. At Morne Bossa the mineralization took place on the edge of a circular dacite porphyry dome, which constitutes the arcuate hills north and west of Morne Bossa. At La Mine the mineralization is closely associated with the Colombo stock of pyroxene dacite.

Hydrothermal Alteration

Mineralization is strongly characterized by a large halo of advanced argillic alteration, containing zones of massive chalcedonic silicification, stockworks, and open-growth barite along multi-generational breccias. The dominant clay mineral is illite with small amounts of alunite. Diaspore and sericite have been reported from the alteration zones of Camp Coq area by Société Minière d'Haiti (1977) and Société Franco-Haitienne des Mines (1980) respectively. All gradations exist between argillization and silicification along strike and dip of the hydrothermally altered zones, as well as from a fresh host rock through chloritized and partly altered rock to a rock completely replaced by silica and clay minerals. Chloritization is mainly confined to the immediate wall rocks but chlorite also mantles sulphide stringers and

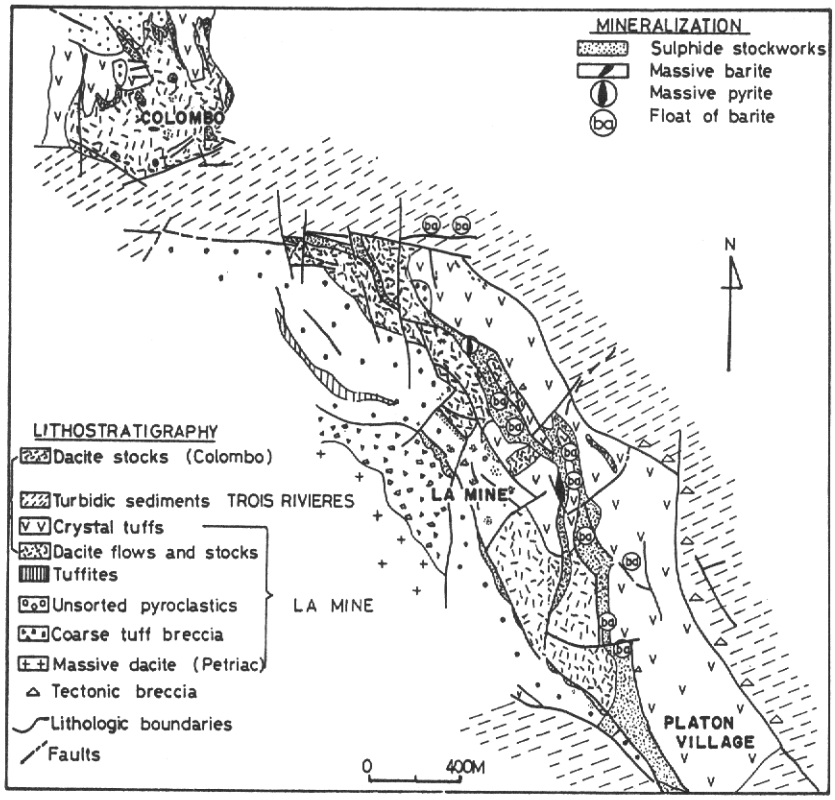

Figure 11. Geological map of La Mine-Colombo area. Reduced from 1:2,000 maps (Louca 1985).

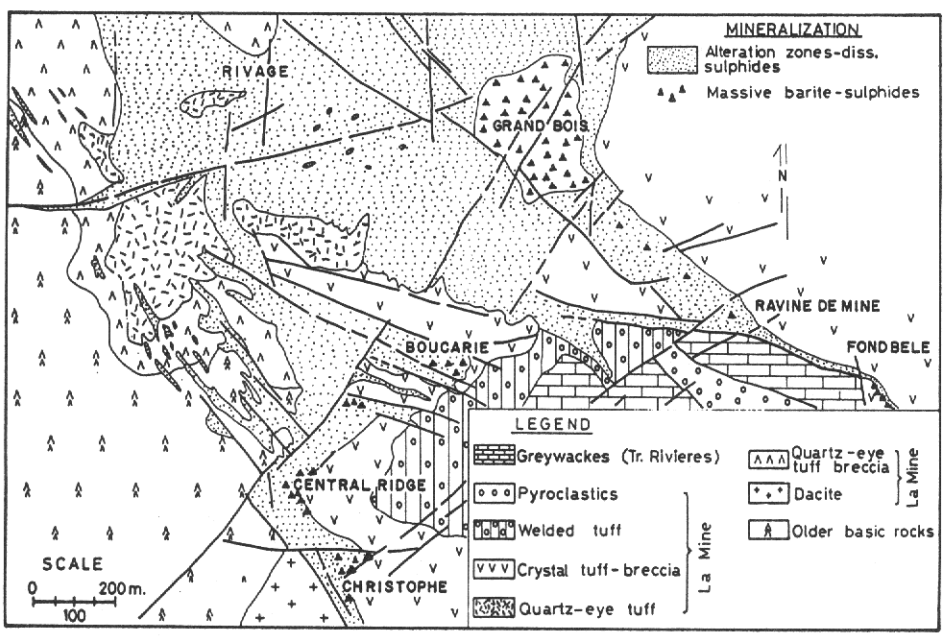

Figure 12. Geological map of Grand Bois-Camp Coq area. Reduced from 1:2,000 maps (Louca 1987).

occurs as filling fractures, and along slips and joint planes.

Sulphide Stockwork

Sulphide stockwork mineralization with variable amounts of barite, is the most widespread and characteristic type of north Haitian epithermal mineralization and is hosted in pervasively altered zones, fault zones, and tectonic and hydrothermal breccias. Mineralization varies from a few tens of meters to 200 meters in width and it may exceed 2 km and 200 meters in strike length and depth respectively. The stockwork zones of La Mine (Fig. 11) consist of a number of bifurcating, steeply dipping fault strands varying in width from a few meters to 100 meters. In the Camp Coq area the focus of the mineralization is centered over the Grand Bois gold deposit, where it extends southwestward and southeastward along fault zones up to 200 m in width (Fig. 12).

Sulphide mineralization consisting mainly of pyrite with small amounts of chalcopyrite, sphalerite and galena, takes the form of heavy disseminations, fracture and cavity infillings and a random network of stringers. The total sulphide content ranges from 3 to 50% and varies considerably along strike and depth, lacking any zonation. Pyrite content increases directly with the intensity of silicification and argillization. Chalcopyrite and sphalerite are more frequent in narrow veinlets and irregular fracture fillings than in disseminations and locally attain widths up to one meter. Although copper and zinc may attain grades of 10 to 25% in the individual fractures and veinlets, their average contents in the stockwork zones are less than 1%. The overall gold contents of the stockwork zones are generally less than 1 g/t. Higher gold values which range up to 9.0 g/t are always associated with the abundant barite.

Barite is widespread in the stockwork zones and in the immediately adjacent hydrothermally altered rocks and occurs in the following more frequent forms: interstitial material with sulphides, stringers, veinlets, veins and gangue in the sulphide stringers. The barite veins range up to three meters in width and are usually enveloped by zones of "mixed" silica and barite. Vein-type and cavity-filling barite is coarse-grained and varies in colour from grey to white according to its sulphide content.

Massive Sulphide-Barite Mineralization

The massive sulphide-barite occurrences have restricted and patchy distribution in the stockwork zones and take the form of irregular fracture-fillings and in-situ replacements and veins. In general, they show lensoid and tabular bodies which range in thickness from 0.6 m to 6.0 m and have strike lengths which vary from 10 m to 90 m. Their contacts with the stockwork zones or hydrothermally altered rock are usually sharp but in some cases gradational. At La Mine a massive powder-fine pyrite body (20 x 10 x 5 m) grades in all directions through semi-massive pyrite to silica with high amounts of pyrite and at Grand Bois (Camp Coq area) irregular bodies of massive barite grade laterally and vertically through semi-massive barite to baritized - silicified and pyritized tuff. The massive sulphide-barite mineralization occurs at various stratigraphic horizons even within the same locality. In the Camp Coq area, the massive sulphide-barite occurrences have a general tendency to concentrate at the outer margins of the stockwork zones but their hanging walls are always formed by pervasive argillic alteration and in most cases are marked by low-angle microshears or steep by dipping fault. In most cases the massive mineralization is oblique to the strike and often to the bedding of host rocks but in a few cases is conformable with the bedding, forming stratiform replacement bodies. Perhaps the best examples of stratiform replacement bodies are those of Christophe and Rosses in the Camp Coq area. An example of cross-cutting relationships between massive ore and host rock is La Cour in the La Mine area. Here a barite-sulphide lense 100 m long and 2 to 6 m wide enveloped by argillic alteration is dipping steeply to the southwest whereas the host volcaniclastics are dipping 50° to 60° to the northeast.

Barite and sulphides occur together in various mineral associations and proportions forming massive ore composed of up to 87% $BaSO_4$ and up to 70% sulphides by volume. In general the barite-sulphide ores are massive and compact but with the leaching of sulphides in the zones of intensive oxidation, the barite may be very porous and spongy. They vary in colour from grey to black dependent on the amount of sulphides, particularly of black sphalerite. The most common sulphides associated with the barite are: pyrite, chalcopyrite, sphalerite, and galena. Sulphosalts of the tennantite series that are present include tetrahedrite and enargite. Geochemical associations are Hg, Sb, As and Mo. Base and precious metal contents vary considerably on an outcrop and district-scale. Copper contents range up to 9%, zinc up to 22%, lead up to 2%, gold up to 12.0 g/t and silver up to 150 g/t. An intimate association of precious metals with barite is typical of all epithermal occurrences in northern Haiti, and in the zone of oxidation leached barite contains up to 48.5 g/t Au and 640 g/t Ag. High gold concentrations occur in locally developed silica boxworks in the oxidation zone of Morne Bossa. Gold in the hypogene zone is bound with sulfosalts and silver sulphides and in the oxidation zones occurs as native gold.

Textures and structures also vary considerably. In general, barite is holocrystalline, medium to coarse grained, and consists of euhedral to subhedral crystals intergrown with sulphides or replacing sulphides. Barite zonally replaces sphalerite and chalcopyrite. Colloform textures and banding of barite with sulphides occur locally in the finer varieties but cataclastic textures and multi-generational breccias occur frequently in all types of ores. Multi-generational breccias in the stockwork zones point to prolonged and episodic mineralization with emplacement of massive barite-sulphides following an initial brecciation and pyritization.

INTERPRETATION

The most important events in the geological and metallogenic evolution of the Massif du Nord of northern Haiti are the La Mine dacite volcanism (Upper Cretaceous) and the Loma de Cabrera tonalite magmatism (Upper Cretaceous - Paleocene). One of the most important contributions of our studies is the recognition and classification of the two principal mineralization systems - epithermal and porphyry copper - and the important role played by the above geological events in their formation in this region. However, the volcanological evolution of La Mine Series and its magmatic affinities are poorly understood and there is only limited information from which we can deduce the relationship of the two principal mineralization systems and constrain their ages. Detailed geological mapping and extensive radiometric dating will be necessary to supplement the available data before final conclusions can be made.

The epithermal mineralization cuts the entire Upper Cretaceous volcanic sequence and the base of the Trois Rivières Series, suggesting that hydrothermal activity occurred during the later stages of acid volcanism. Based on their studies in the Dominican Republic, Amarante et al. (1989) and Lewis et al. (1989), consider that the main fractures providing fluid conduits for hydrothermal activity in the Upper Tireo (La Mine Series) would have been developed in the Campanian at the latest. The available age dating on the epithermal-polymetallic mineralization in both Haiti and Dominican Republic show dates that extend from 85 to 59.4 Ma, spanning the entire Campanian - Lower Paleocene (Danian) period and indicating more than one episode of hydrothermal activity. Reported ages in Haiti include K/Ar dates of 84 Ma on sericite from the hydrothermal alteration at Camp Coq (Société Minière d'Haiti, 1977) and concordant Rb/Sr and K/Ar ages of 59.4 Ma on mineralized dacite stocks at Mazambi (Cheilletz et al., 1978). Whole rock K/Ar dates ranging from 71 to 85 Ma were reported on mineralized felsic intrusions of the Tireo Group in the Dominican Republic (Electroconsult, in Lewis et al., 1989).

Information on the epithermal mineralization suggests times of hydrothermal activity which coincide with the main phases of the Loma de Cabrera magmatism. In a subjective way the writer feels that some of the dacite stocks with associated mineralization, may represent a shallow level manifestation of the tonalite magmatism or subjacent porphyry copper stocks (Louca, 1985). Similar conclusions have been reached by Lewis et al., (1989), who also considers that it is likely that the dacite volcanism of the Upper Tireo unit (La Mine Series) is the volcanic equivalent of the tonalite plutonism. It would appear that the early phases of the Loma de Cabrera tonalite magmatism gave way to the La Mine volcanics which, at a much later stage, were intruded by their parent tonalite rocks (Fig. 13).

Although the relation between the tonalite batholith and the small shallow porphyry stocks of microtonalite and quartz diorite, as well as many aspects of the associated porphyry copper

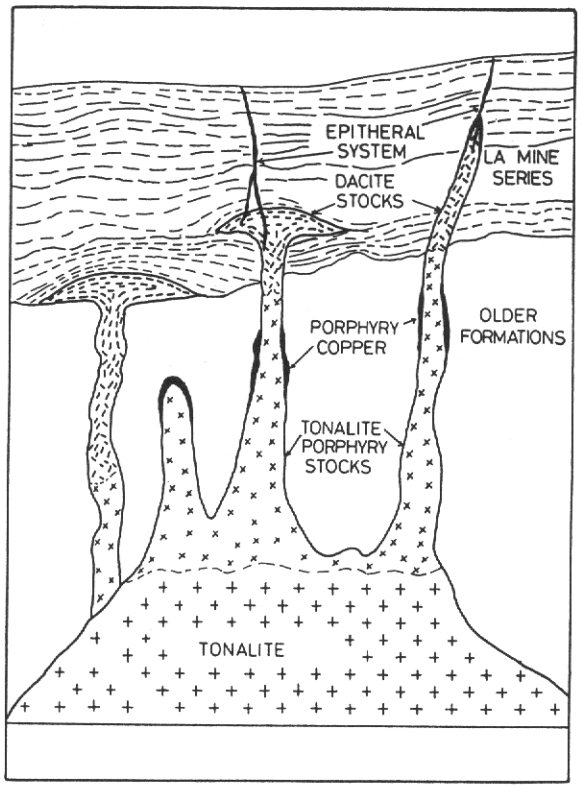

Figure 13. Idealized model of possible relationships between the epithermal and porphyry copper mineralization (Louca 1987).

mineralization have been a source of heated controversy, there seems little doubt that these stocks represent high level periplutonic intrusions of the tonalite magmatism. This relationship is not always obvious because the ages of both stocks and batholith are poorly constrained and the various generations of tonalites have not yet been differentiated in the Massif du Nord. Field evidence partly supported by radiometric age dating point to emplacement times of both the stocks and the batholith that range from Upper Cretaceous to Paleocene. Age dating of Rb/Sr and K/Ar on the Terre Neuve stocks (Kesler, 1968) and Jean Rabel stocks (Cheilletz et al., 1978) gave 66 Ma and 67 + 4 Ma respectively.

With regard to the origin of precious metals of the two principal mineralizations of northern Haiti, our studies allow interpretations only for the porphyry copper group deposits. Lithogeochemical work on rock samples from the Grand Bassin area shows that the ultrabasic and basic rocks, as well as the lower members of the Perches Series can be chemically distinguished from the other formations by their high Ni and Au contents which range up to 1600 ppm and 50 ppb respectively. In the Faille B area the hydrothermally unaltered Perches Series containing intercalated thin barite layers, is characterized by values up to 1700 ppm Pb, 1000 ppm Zn, 7 ppm Ag and 200 ppb Au. Within the hydrothermally or sheared Perches Series and ultrabasic rocks, Ni decreases to 360 ppm, Zn to 50 ppm, Pb to 26 ppm Au to 30 ppb respectively.

This phenomenon of depletion of base and precious metals from the hydrothermally altered rocks and their concentration in quartz veins, as well as the close spatial relationship of these gold-bearing veins with ultrabasic and basic rocks, suggest that at least part of the gold in quartz veins was generated from these rocks. This interpretation of metal source rocks applies equally well to both gold bearing stocks and silver-rich vein deposits hosted in metabasic and ultrabasic rocks elsewhere in the Massif du Nord.

Although our studies have demonstrated an intimate association between gold and barite in the epithermal mineralization system, additional information is needed in order to understand the factors affecting the mobilization and Olocalization of the gold during the various episodes of hydrothermal activity.

SUMMARY AND CONCLUSIONS

The present study has isolated two principal genetic types of economic sulphide and gold mineralization in northern Haiti: porphyry copper-bearing stocks and epithermal-polymetallic sulphide-barite mineralization. The first one is related to quartz diorite stocks and includes a continuum between porphyry copper deposits, limestone replacement (skarn) deposits and gold bearing quartz-sulphide veins. These deposits are known from the deeper and central parts of the Upper Cretaceous volcano-sedimentary pile (andesites and basalts) and from tectonic zones in older formations. Epithermal-polymetallic mineralization exhibits volcano-tectonic control and is characteristically associated with zones of silicification and advanced argillic alteration at the higher levels of the same volcanic pile (dacitic La Mine Series).

Although the author's studies on northern Haiti have given a better appreciation of the classification of the mineral deposit types and their association with certain lithologic units and rock types, considerably more work needs to be done on the individual mineralized systems to better understand their genesis and emplacement history in terms of time. The time of emplacement of the porphyry copper-bearing stocks and the dacite stocks with related epithermal mineralization falls within the Upper Cretaceous-Paleocene interval, coinciding with the tonalite plutonism. However, the genetic and temporal relationships between the two principal mineralized systems have not yet been defined. The epithermal system may be underlain at depth by porphyry copper stocks in a polygenetic volcanic setting such as a stratovolcano-flow dome complex similar to those described by Sillitoe and Bonham (1984) in the western Americas and the southwest Pacific.

Further exploration for base and precious metal mineralization in northern Haiti is considered to be a worthwhile undertaking. Despite the unanswered questions on the emplacement history and origin of the north-Haitian mineralization the present work has provided valuable information and features which have an important bearing on future exploration programmes. Utilizing this information the exploration strategy should be modified in accordance with the following:

a. Mémé skarn deposit reported in literature as a copper mine, contains appreciable amounts of gold and silver. Resampling of various parts of the deposit indicated gold contents up to 23 g/t and sizeable portions of the mine may average about 10 g/t Au. So far, exploration efforts have been focused only on skarn mineralization with surface expression and even in those cases, mineralization has not been fully delineated. The structural disposition of the quartz diorite stocks and related skarn deposits, suggest possible sub-surface extension of the mineralization between the individual stock outcrops and additional ore potential.

b. The evaluation of the two major porhyry copper deposits, Douvray and Blondin, carried out in the late 1970's aimed at their copper ore reserves and the information on their precious metal content is very sporadic. Selected drill holes from Blondin deposit analyzed for gold show intersections over one meter in width with 9.0 g/t Au. In view of the significant potential of mineralized ground (combined 250 million tonnes with 0.6% Cu) the assessment of these two deposits for their precious metal content is strongly warranted.

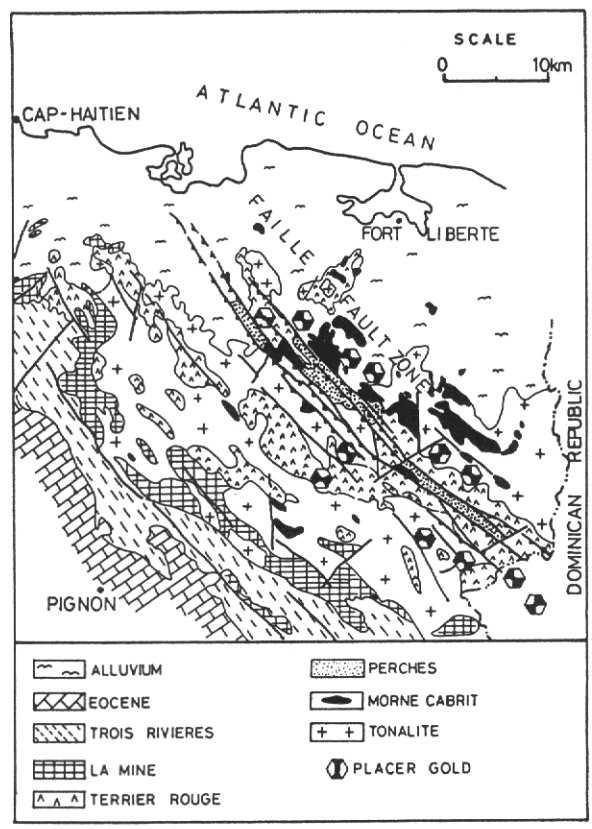

Figure 14. Geological map of Northeastern Haiti (Louca 1988).

c. Field evidence supported by regional air photo interpretation and geochemical data suggest that the Faille Fault Zone containing the Faille B gold deposit, extends northwest towards the Blondin porphyry copper deposit and to the southeast through Mont Organisé to the Dominican Republic (Fig. 14). The projection of a major fault zone is further supported by the distribution of the occurrences of alluvial gold at Acul de Pins, Vallières and Mont Organisé.

d. Although the targets sought in the primary zone of the epithermal mineralized system are small, their high gold contents make them deserving of further attention. The lack of exploration success in locating economic ore bodies may be attributed to the fact that exploration to date has been concentrated on the search for syngenetic and concordant bodies of massive mineralization instead of focusing on steep fault zones and planes of the mineralized structures within which the massive sulphides-barite replacements are likely to be elongated.

ACKNOWLEDGEMENTS

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