Current Research (1990) Newfoundland Department of Mines and Energy, Geological Survey Branch, Report 90-1, pages 217-225

MINERALIZATION AND ALTERATION STUDY OF THE MAIN OREBODY, CONSOLIDATED RAMBLER MINES, BAIE VERTE, NEWFOUNDLAND

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ABSTRACT

The Consolidated Rambler Mines property is located in the north-central area of the Baie Verte Peninsula. Between 1962 and 1982, it produced more than 4 million tonnes of Cu–Au ore from four volcanogenic sulphide deposits. In 1988, an exploration program was initiated to delineate any remaining base- and precious-metal reserves and explore for new deposits on the property. One of the main targets was mineralization associated with the Main (Rambler) Mine.

The present study was initiated in July, 1989. The purpose of the study is to relate different sulphide and alteration assemblages to discrete metallogenic events, particularly those related to gold distribution in the Main (Rambler) Mine. Three types of sulphide ore have been recognized: (1) synvolcanic, strataform volcanogenic massive sulphide, which is concentrated toward the top part of the orebody; (2) epigenetic shear-hosted mineralization, which overprints the primary massive sulphide and is generally associated with the footwall of the orebody; and (3), late-stage epigenetic veins that crosscut all rock types.

Studies of modern-day seafloor massive sulphide accumulations reveal that many have anomalous syngenetic gold concentrations, suggesting that some of the gold associated with the massive sulphide zone in the Main (Rambler) Mine may also be of a primary nature. However, studies have described epigenetic shear-hosted gold mineralization located throughout the Baie Verte Peninsula, and this late gold event may also be important in the Main (Rambler) Mine. Preliminary examination of mineralization at the Main Mine suggests that some gold is associated with the shear-hosted and epigenetic types of mineralization, and as such, future work will concentrate on improving the distinction between the three types of ore and on assessing the metallogenic significance of later shear-hosted and epigenetic veining events.

INTRODUCTION

The Consolidated Rambler Mines property is located at the intersection of Routes 414 and 418, 18 km east of the community of Baie Verte, in the north-central part of the Baie Verte Peninsula (Figure 1). Between 1962 and 1982, the property produced more than 4 million tonnes of Cu–Au ore from four volcanogenic sulphide deposits (Tuach *et al.*, 1988). The geology and history of the property have been described by several authors including Baragar (1954), Gale (1971, 1973), Heenan (1973), Tuach (1976), Tuach and Kennedy (1978), Hibbard (1983) and Tuach *et al.* (1988).

In 1987, the mineral rights to the Rambler properties reverted to the Crown and were awarded to three joint-venture partners; Petromet Resources, Newfoundland Exploration, and Teck Corporation. An exploration program was initiated to delineate any remaining base- and precious-metal reserves and explore for new deposits on the property.

One of the main targets was the mineralization associated with the Main (Rambler) Mine. Of particular interest was a footwall zone of sheared, auriferous, disseminated mineralization, previously located, but not fully explored. A diamond-drilling program was initiated to test the extent of this mineralization. The program consisted of a total of approximately 600 m of surface diamond-drilling, which was completed in 5 fences across the Main zone.

The present study was intiated in July, 1989. The following is a summary of the preliminary observations obtained during a six-week, field-work period. The program consisted mainly of logging drill core, with emphasis on the type and spatial distribution of mineralization and alteration. The purpose of the study is to relate different alteration and sulphide assemblages to different metallogenic events. In particular, the study will attempt to identify a syngenetic gold event as being distinct from a later shear-hosted gold event. The geochemical signatures and alteration assemblages associated with these different gold events will be fully characterized. Although approximatley 300 m of core were examined, present observations and discussions are limited to a subset of the available data, which contains most of the pertinent relationships.

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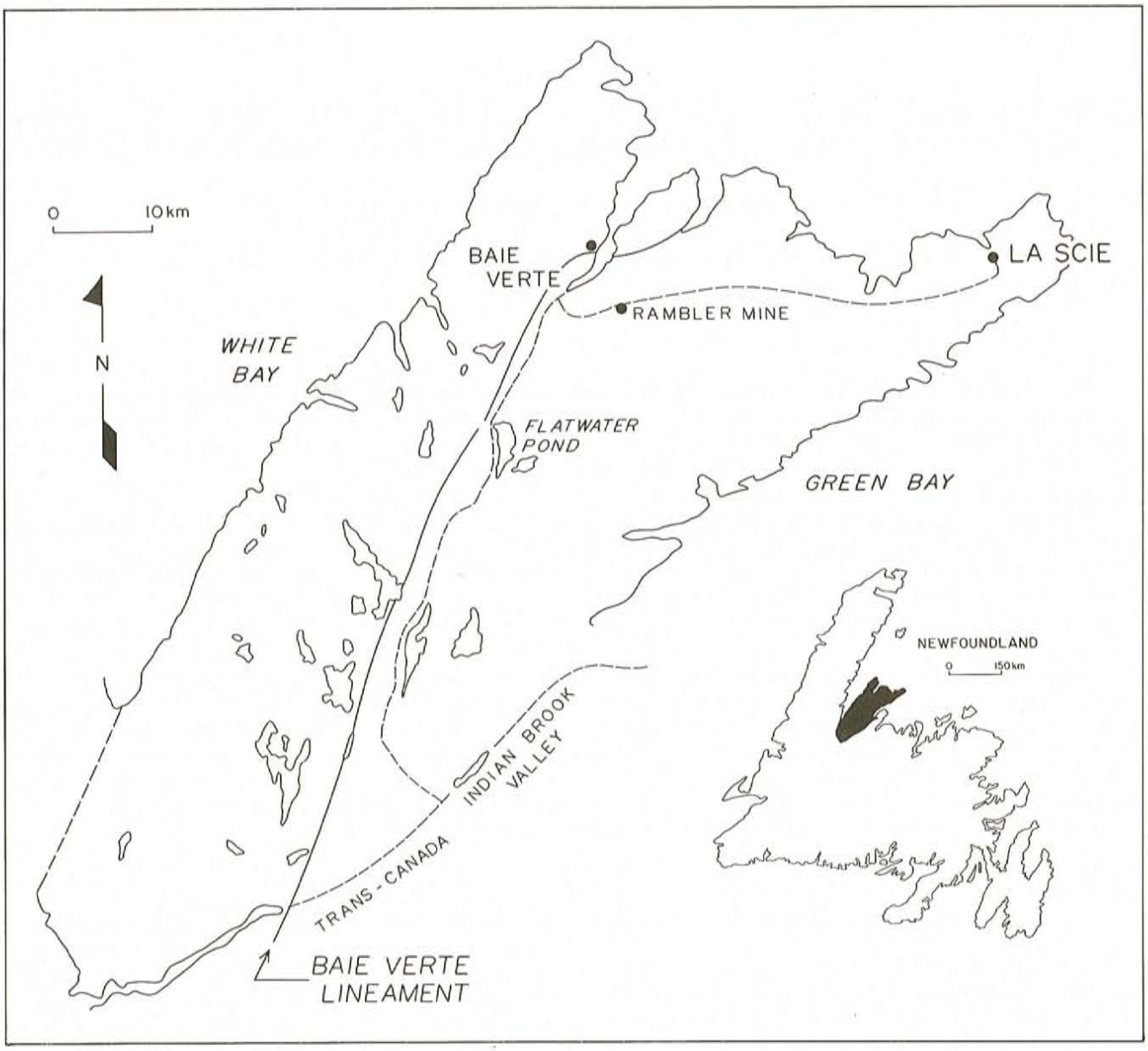

Figure 1. *Location map, Consolidated Rambler Mines, Baie Verte Peninsula.*

REGIONAL GEOLOGY

The Consolidated Rambler Mines property and Main (Rambler) Mine massive sulphide deposit occur within the Pacquet Harbour Group; a polydeformed sequence of volcanic and sedimentary rocks metamorphosed to upper greenschist or lower amphibolite facies. The internal stratigraphy and lithological relationships within the Pacquet Harbour Group are not well constrained due to a lack of outcrop, complex internal structural relationships and a lack of detailed geological mapping. Geological mapping of the Rambler property resulted in the recognition of an east-striking, moderate northerly dipping metavolcanic sequence consisting of metamorphosed mafic flows and volcaniclastics, felsic volcaniclastics and mafic intrusives having minor occurrences of ultramafic rock, chert and silicic rocks (Tuach, 1976). These units are intruded by the Early Ordivician Burlington Granodiorite to the west and Siluro-Devonian Cape Brule Porphyry immediately northeast of the property boundaries.

Whole-rock geochemical analysis of basalts in the Rambler area has identified a suite of tholeiitic basalts as distinct from a suite of high magnesian, incompatible element-depleted volcanic rocks referred to as 'basaltic komatiites' (Gale, 1971). Hibbard (1983) reported additional geochemical analyses of these units and noted the chemical similarities of these volcanic rocks to boninites. In subsequent geochemical work, extended REE plots and Nb/Th ratios plotted against Y have been used to relate these units to a tectonic transition between arc and non-arc environments (Swinden *et al.*, 1989).

Felsic volcanic and volcaniclastic units form a base for the stratigraphy within the property boundaries. These felsic units are exposed in the centre of the property as a series of prominent outcrops, immediately northeast of the mine site. They are overlain by mafic volcanic and volcaniclastic units exposed in the eastern portion of the property, separated by a poorly defined transition zone of variably tectonized mafic and felsic rocks.

All rocks in the Rambler area are deformed. Tuach (1976) has described four phases of deformation in the Ming Mine area. These separate phases of deformation, including both ductile and brittle phases, may be related to stratigraphic and other pre-existing structural anisotropies. Hibbard (1983) has suggested that the second phase (main deformation) produced intense penetrative transposition subparallel to primary layering (Plate 1). Stereographic projections of poles to cleavage, as defined by schistosity and compositional layering (preliminary mapping, MPH Exploration Limited) and mineral and particle lineations associated with this deformation (Tuach, 1976), are shown in Figures 2a and b.

Five principal sulphide deposits occur on the Rambler property including the Ming Mine, the newly discovered Ming West, the Main (Rambler) Mine and the East and Big Rambler deposits. The shape and orientation of these deposits have been modified during the main event of deformation. Consequently, the Ming and Ming West, East and Main (Rambler) Mines are elongate parallel to the measured orientation of mineral and particle lineations defined in outcrop. Figure 3 shows the position of these three orebodies

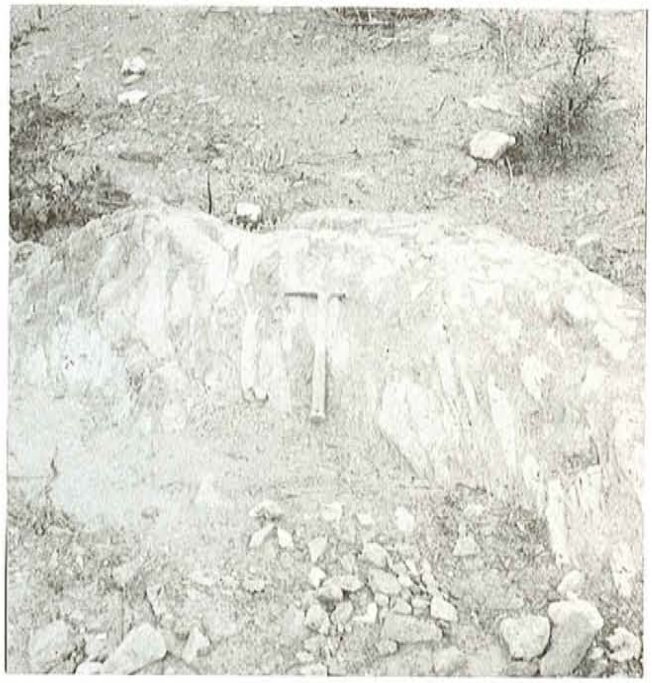

Plate 1. *Stretched felsic clasts in agglomerate, demonstrate extensional deformation subparallel to primary layering; roadside exposure, approximately 200 m southeast of Main (Rambler) Mine site.*

at different stratigraphic intervals relative to the inferred contoured transition between felsic and mafic units (D.

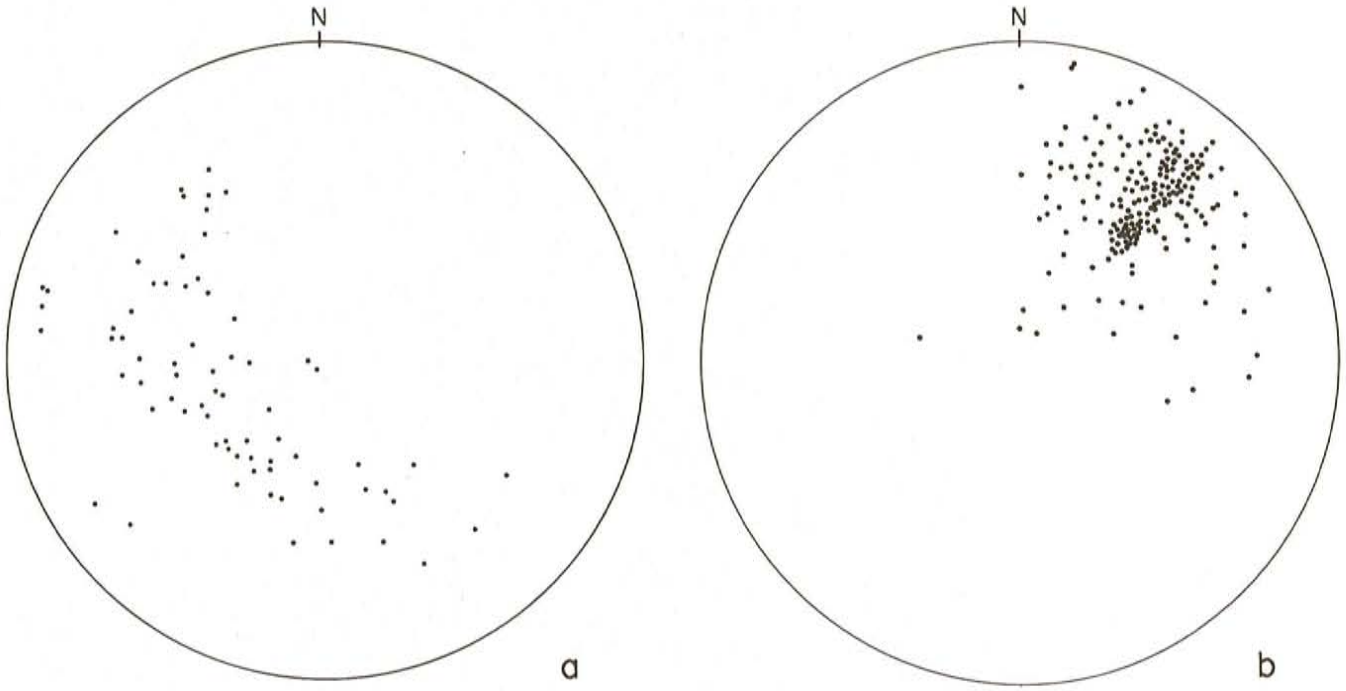

Figure 2. *a) Stereographic projection; poles to cleavage defined by compositional layering (SI=S2) and schistosity measured during preliminary mapping (MPH Exploration Ltd.), b) Stereographic projection; projection of mineral and particle lineations in the Rambler area (Tuach, 1976).*

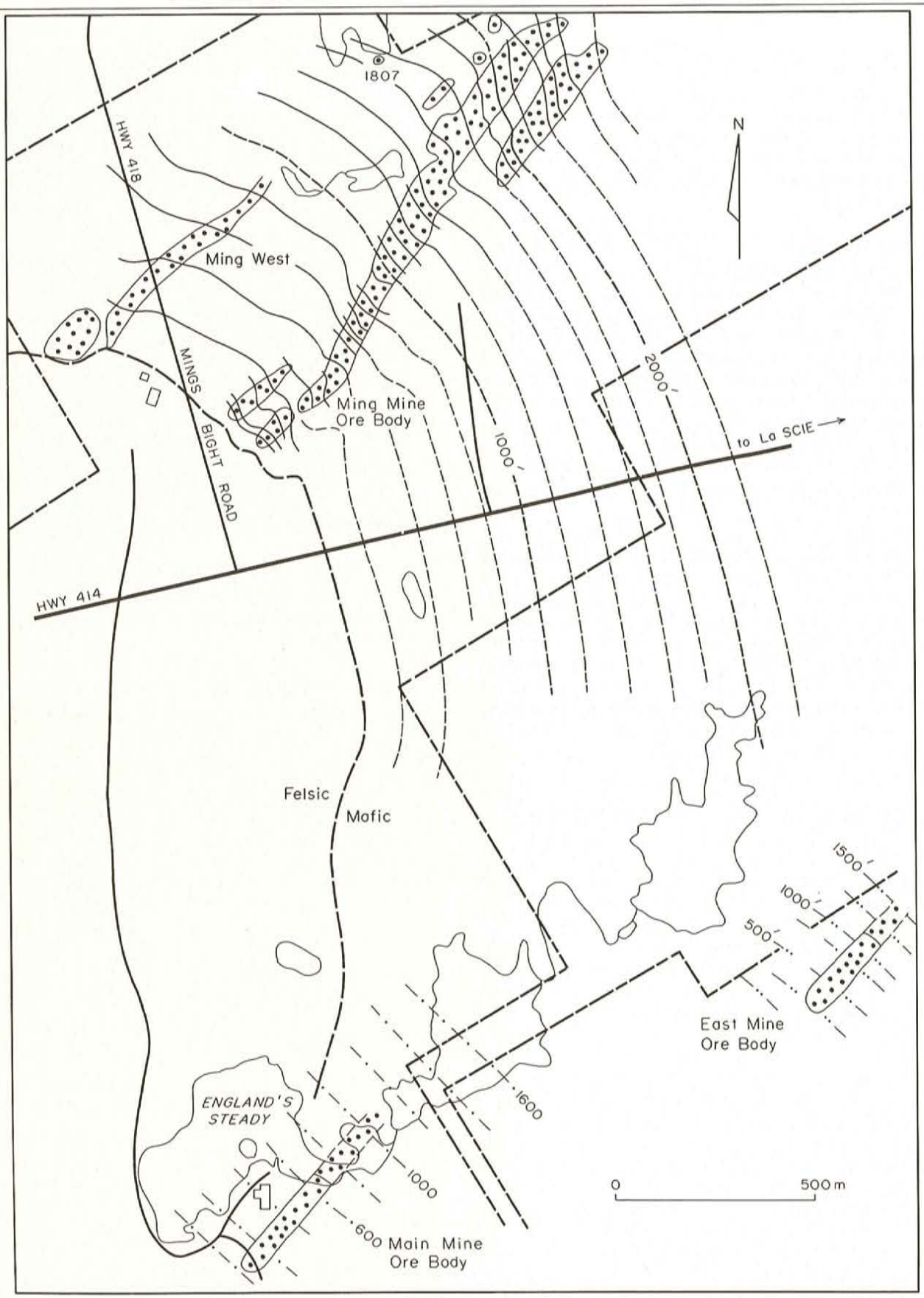

Figure 3. *Consolidated Rambler Mines property map showing location of mines and associated orebodies. Inferred stratigraphic positions relative to contoured felsic–mafic transition in volcanic rocks (D. Duncan, MPH Exploration Ltd., personal communication, 1989).*

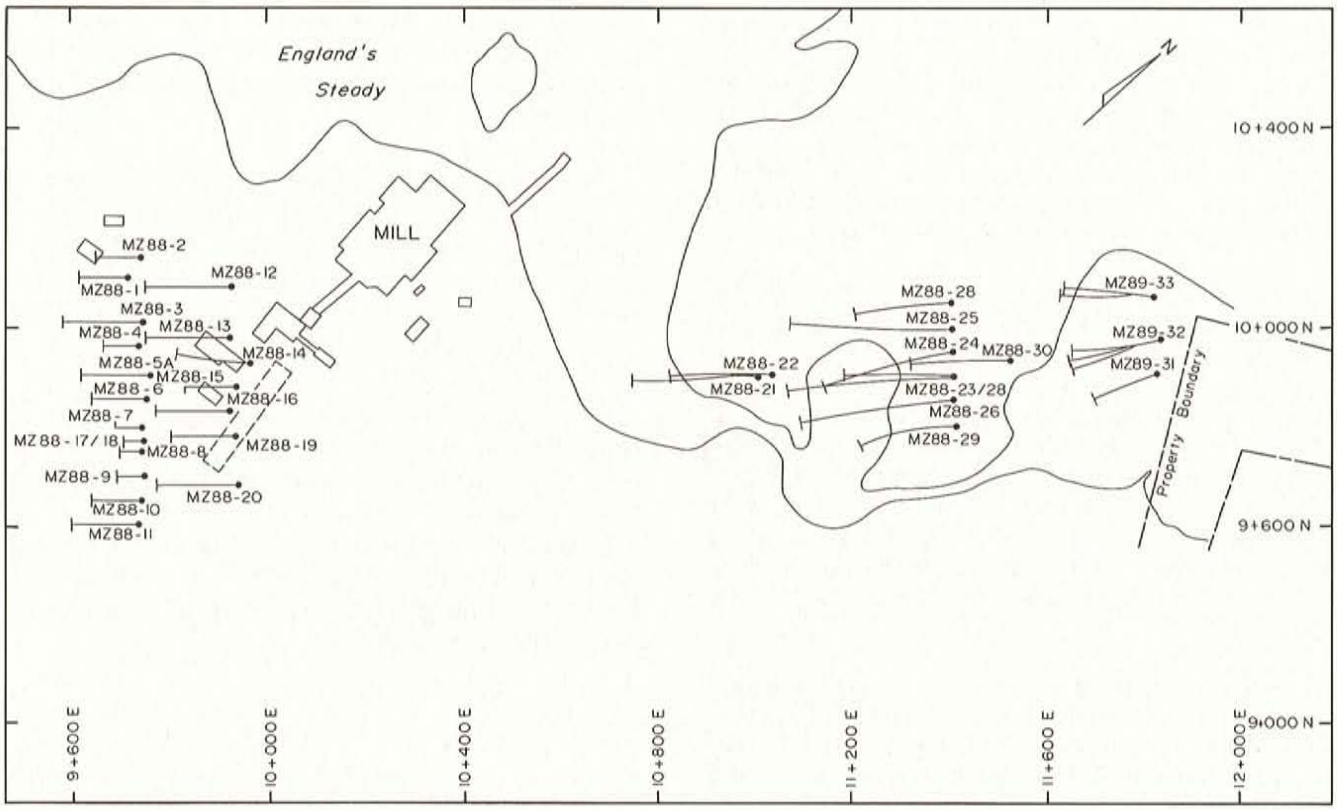

Figure 4. *Drillhole location map; position of drillholes relative to surveyed grid lines.*

Duncan, MPH Exploration Limited, personal communication, 1989). Figure 4 shows the position of the drillholes in the study area relative to surveyed grid coordinates.

GEOLOGY OF THE MAIN (RAMBLER) MINE

The Main (Rambler) Mine is located in the centre of the claim group and has been described as an elongate tapered linear shoot that follows the axis of a northeast-plunging fold (Gale, 1971). The orebody has a strike length of about 100 m and maximum thickness of 16 m near the surface (Tuach, 1976). The current drilling program traced the extension of the orebody to an estimated vertical depth of approximately 600 m.

The drill core reveals an apparently conformable sequence of mafic volcanic, intrusive and volcaniclastic units. A series of variably sheared and silicified basalts appear immediately below the orebody. The more silicified and altered units may represent the original stockwork to primary massive mineralization in the Main Mine. In drill core, these altered units consist of dark green, fine grained, banded quartz–chlorite schists having variable amounts of disseminated pyrite (up to 30 percent) and minor amounts of chalcopyrite (5 percent).

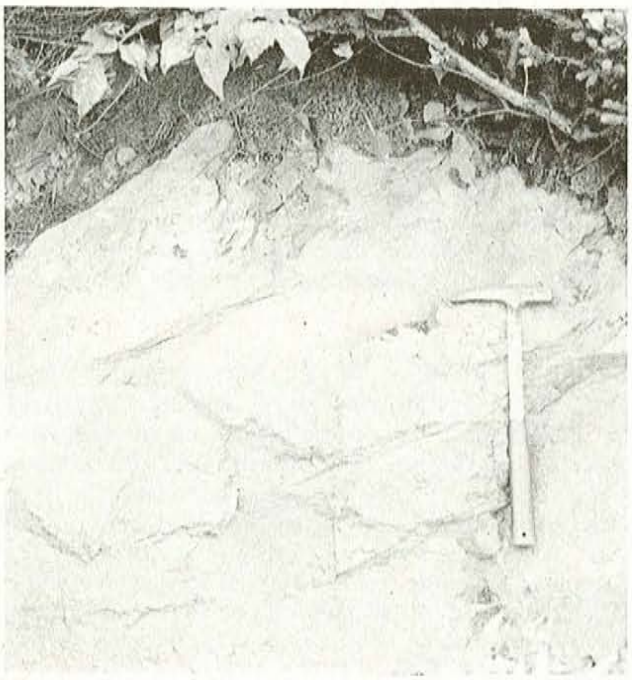

Plate 2. *Pillowed basalt found in the hangingwall of the Main (Rambler) orebody; exposed in roadside outcrop, 100 m east of Main (Rambler) Mine site.*

A series of mixed mafic flows occurs immediately above the orebody (Plate 2). In drill core, these appear as dark green, fine grained, chloritized basalts, which contain minor amounts of intercalated volcaniclastic sediment with red,

subangular, magnetic cherty fragments. Primary igneous features such as flow breccia and pillows are infrequently seen in core, within intervals of low strain. In more highly strained intervals, quartz chlorite schists predominate with dark, bluish-green silicified bands. In thin section, basalts are variably altered to an assemblage consisting mainly of chlorite having lesser sericite, quartz, actinolite and albite. Discrete porphyroblasts of biotite describe a planar fabric.

Mafic flows above the deposit are intruded by a variably differentiated gabbro sill, up to 100-m thick. Several distinct phases of the gabbro have been recognized. The top of the sill is a brownish, medium grained, equigranular magnetic phase containing irregular patches of quartz–calcite–epidote alteration. In the middle of the sill, the gabbro varies between a light grey to greenish grey, coarse cummulate phase and a dark grey, fine grained massive phase. The bottom of the sill consists of a light green, fine grained porphyritic gabbro having sericitized porphyroblasts of plagioclase (2 to 5 mm). Further work is required to resolve the different phases of the gabbro.

Contact relationships between the gabbro and host rocks are commonly difficult to interpret. Some contacts can be defined only by the presence of leucoxene (associated with the gabbro) on one side of the contact boundary. Others have chilled margins where increased alteration in the surrounding rock is evident.

Mafic flows and gabbro are overlain by a succession of massive and pillowed mafic flows and volcaniclastic sediment. The mafic flows in this part of the stratigraphy are variably sheared and metamorphosed to regional, upper greenschist or lower amphibolite assemblages. Distinct pillow selvages, amygdules and flow breccia are common in some intervals. Volcaniclastic sediments include mixed felsic and mafic agglomerate, chert conglomerate, greywacke and tuff. Clast brecciation and elongation are characteristic in areas of high ductile strain. Well-developed extension lineations can be observed on fracture planes parallel to fracture cleavage and schistosity.

Different generations of mafic dykes and sills intrude all units of the stratigraphy, including the ore zone. These dykes have well-defined intrusive contacts, and in the ore zone, some appear as undeformed fine grained, dark-green dykes, whereas others are notably tectonized. In some cases, these dykes can only be distinguished from similar gabbroic dykes by the absence of leucoxene. Felsic porphyry dykes are generally restricted to specific stratigraphic intervals above the gabbro. These dykes appear to be similar to the fine grained porphyry dykes described in the Cape Brule Prophyry (DeGrace *et al.*, 1975).

Mineralization

Drilling has intersected three zones of sulphide mineralization separated by altered mafic units. Sulphide mineralization in these three zones has been separated into three main ore types. The separation of these three main types is based primarily on distinct hydrothermal alteration assemblages, sulphide mineralogy and associated textural features.

The first ore type is commonly concentrated toward the top part or hanging wall of the orebody. This type of mineralization consists essentially of strataform volcanogenic massive sulphide (VMS). The ore is similar in appearance to other massive ore described VMS deposits (Gale, 1971; Tuach, 1976; Franklin *et al.*, 1981).

The second dominant ore type can be described as epigenetic shear-hosted mineralization (Plate 3). This ore type has been associated with the footwall of the orebody, but is found throughout the orebody overprinting massive mineralization. The alteration assemblages associated with this type of mineralization are similar to the Archean shear-hosted alteration assemblages described in the Norbeau Mine, Québec (Dubé *et al.*, 1987).

Plate 3. *Highly deformed quartz–sericite ± fuchsite–pyrite schist associated with shear-hosted ore; footwall of Main (Rambler) orebody.*

The third ore type consists of late-stage epigenetic veins (Plate 4). This type of mineralization has been intersected by several drillholes below stoped out portions of the mined orebody, and in one of the deeper peripheral holes, immediately north of the extension of the orebody. This type of mineralization consists of large undeformed quartz veins, which overprint the other two types of mineralization.

Plate 4. *Late-stage epigenetic quartz vein; roadside exposure west of East Mine.*

Volcanogenic Massive Sulphide Mineralization. This type of ore is typically overlain by up to 1 m of black magnetic chert, which has been intersected in several of the drillholes. Massive sulphide is defined as >60 percent modal sulphide, and it occurs as lenses of fine- to medium-grained granular to recrystallized pyrite (80 percent), sphalerite (10 to 15 percent) and minor chalcopyrite (<10 percent). Compositional banding in these lenses occurs in areas of higher strain and is the result of variations in the modal proportions of pyrite, sphalerite and quartz.

Localized zones near the bottom of massive mineralization contain breccia ore, of which several textural varieties are common. In intervals of low strain, recrystallized pyrite, minor chalcopyrite and sphalerite surround dark-grey subangular siliceous fragments (2 to 10 cm), which are crosscut by irregular fractures containing fine grained pyrite. As the amount of strain increases, the breccia ore is progressively sheared. In more highly strained intervals, stringer ore predominates, consisting of irregular bands of fine- to medium-grained disseminated sulphide (up to 30 percent pyrite) in greyish-green, fine grained quartz–chlorite to sericite and talc schist. Faults are marked by gouge, which consists of granular pyrite, chlorite, talc and clay.

High concentrations of gold, silver, copper and zinc are characteristic of the massive sulphide horizons. The overlying chert horizons are also enriched in precious metals and one drillhole returned assays in excess of an ounce per ton for gold and silver. Breccia and stringer ore contain lesser anomalous concentrations of these metals.

Shear-Hosted Mineralization. Shear-hosted mineralization overprints the massive sulphide ore zone, and may include the sheared equivalent of primary stockwork mineralization. This zone is generally associated with, but not restricted to, the footwall of the Main (Rambler) Mine. It consists of recrystallized, mylonitic quartz–sericite ± fuchsite–pyrite schists; petrologically similar to the epigenetic A4 and A5 alteration assemblages defined by Dubé *et al.* (1987) for gold mineralization in the Norbeau sill. The strongly deformed nature of this zone has obscured primary features associated with massive sulphide mineralization.

Shear-hosted ore is almost monominerallic with respect to sulphide, containing approximately 25 modal percent of finely disseminated pyrite and trace amounts of chalcopyrite. This ore assays relatively high for gold but is depleted in base metals and silver. Anomalously high assay values for gold are somewhat lower and more evenly distributed than in primary massive sulphide horizons. (Backscatter SEM images (Plate 5) of this ore type reveal that gold is associated with Fe, Ni, and Bi tellurides). The tellurides occur as discrete irregular or polygonal grains (5 to 10 μm) interstital to silicate minerals and pyrite.

Wilton (1989) also describes the occurrence of gold telluride and electrum in samples described as 'footwall stringer veining.' Backscatter images of these samples show discrete grains (up to 5 μm) of gold and silver tellurides interstitial to silicates and sulphide grains.

Epigenetic Vein Mineralization. Late-stage, post-deformational epigenetic vein mineralization is characterized by large irregular (up to 5 m) 'milky-white' quartz veins. Comb textures, pervasive silicification and sulphidization of wallrock and associated angular xenolithic fragments appear in core from drillhole MZ88-28 (Figure 4). A preliminary examination of assay data from these core intervals suggests secondary remobilization and enrichment of gold, zinc and silver.

DISCUSSION

Several authors have described modern-day seafloor hydrothermal systems, where massive sulphide is associated with high concentrations of gold (Hannington *et al.*, 1986; Kappel and Franklin, 1989). Huston and Large (1989) describe and relate the presence and distribution of gold in Archean and younger massive sulphide deposits, to changes in the composition of the hydrothermal fluids as the deposits evolve. These and other studies suggest that massive sulphide deposits like the Main (Rambler) Mine can contain substantial primary gold as part of a synvolcanic mineralizing event. However, the work by Guha *et al.* (1988) on gold

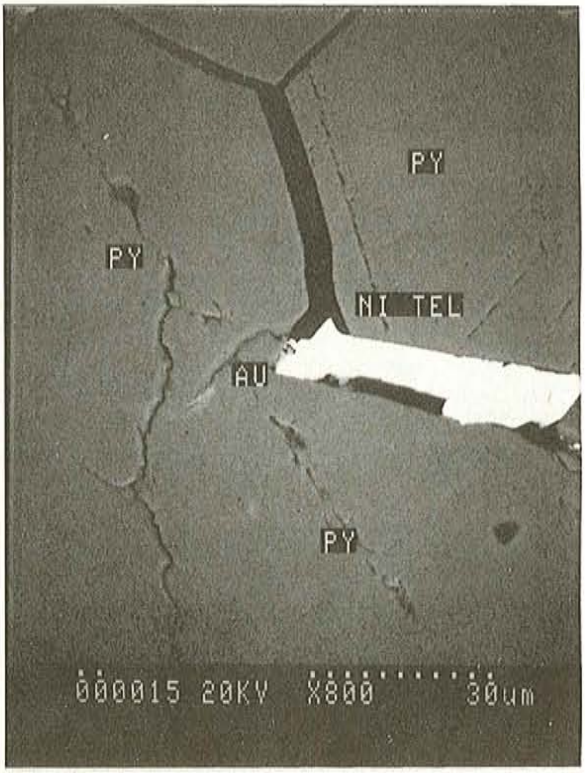

Plate 5. *Backscatter SEM photograph; Au-telluride associated with Ni-telluride interstitial to pyrite in shear-hosted mineralization.*

mineralization in the Archean Lyon Lake massive sulphide deposit, emphasizes the role that later metamorphic and structural events can have on re-distributing gold in these deposits. The remobilization of gold also may be important in the shear-hosted and epigenetic ore of the Main (Rambler) Mine, particularly in light of the work by Tuach *et al.* (1988), who have described numerous occurrences of epigenetic gold mineralization throughout the Baie Verte Peninsula. The examination of rock types, structural relationships and alteration assemblages appear to indicate that the shear-hosted mineralization in the Main (Rambler) Mine is secondary with respect to primary volcanogenic massive sulphide mineralization, and more work is needed to establish whether gold is similarly late in origin.

SUMMARY

In summary, gold is found throughout the orebody of the Main (Rambler) Mine but its pattern of distribution does not suggest either a uniquely syngenetic or an epigenetic origin. Work completed to date has concentrated on identifying the main rock units, the major ore types and the alteration assemblages found in drill core. Further work will focus on improving the distinction between the three main types of ore to assess the metallogenic significance of the shear-hosted and epigenetic vein events. In particular, the study will attempt to resolve whether gold in the massive sulphide zone is exhalative and whether it can be distinguished from gold related to later events.

To constrain the origin of gold mineralization, additional work will be undertaken to establish petrographic relationships, such that samples can be selected for chemical and isotopic analysis, in an attempt to establish the existence and nature of the different fluids, which have affected the deposit. Variations in the chemical compositions of sulphide phases, and alteration minerals such as chlorite, and the presence and chemical composition of other trace hydrothermal phases such as tourmaline, should provide a basis for the distinction between hydrothermal fluid sources related to the different types of mineralization. Petrography has identified numerous other alteration minerals that could be utilized, including several textural varieties of hydrothermal quartz, sericite, epidote, carbonates and various sulphide and oxide minerals. The determination of chlorite/sericite ratios may allow constraints on the relative intensities of locallized alteration.

ACKNOWLEDGMENTS

Access to the drill core was graciously provided by MPH Exploration Limited. Their support of JW in the field and discussions with Howard Coates, Debborah O'Connor and Dave Duncan are greatly appreciated. Financial and technical support from the Newfoundland Department of Mines and Energy is gratefully acknowledged. Drafting was completed under the supervision of Ken Byrne at the Newfoundland Department of Mines and Energy.

REFERENCES

Baragar, W.R.A.
1954: Geological report–Rambridge Mines Ltd. Consolidated Rambler Mines Ltd., unpublished report.

Dubé, B., Guha, J. and Rocheleau, M.
1987: Alteration patterns related to gold mineralization and their relationship to CO_2/H_2O ratios. Minerology and Petrology, Volume 37, pages 267-291.

Degrace, J.R., Kean, B.F. and Besaw, D.H.
1975: Geology of the Nippers Harbour map area (2E/13). Newfoundland Department of Mines and Energy, Mineral Development Division, Open File Nfld. 788, 59 pages.

Franklin, J.M., Lydon, J.W. and Sangster, D.F.
1981: Volcanic-associated massive sulfide deposits. Economic Geology, 75th Aniversary Volume, pages 485-627.

Gale, G.H.
1971: An investigation of some sulphide deposits of the Rambler area, Newfoundland. Unpublished Ph.D. thesis, University of Durham, England.

1973: Paleozoic basaltic komatiite and ocean floor type basalts from northeast Newfoundland. Earth and Planetary Science Letters, Volume 18, pages 22-28.

Guha, J., Dubé, B., Pilote, P. and Chown, E.H.
1988: Gold mineralization patterns in relation to the lithologic and tectonic evolution of the Chibougamau mining district, Quebec, Canada. Mineralium Deposita, Volume 23, pages 293-298.

Hannington, M.D., Peter, J.M. and Scott, S.D.
1986: Gold in sea-floor polymetallic sulfide deposits. Economic Geology, Volume 81, pages 1867-1883.

Heenan, P.R.
1973: The discovery of the Ming zone, Consolidated Rambler Mines Limited, Baie Verte, Newfoundland. Canadian Institute of Mining and Metallurgy Bulletin, Volume 66, Number 829, pages 78-88.

Hibbard, J.
1983: Geology of the Baie Verte Peninsula, Newfoundland. Newfoundland Department of Mines and Energy, Mineral Development Division, Memoir 2, 279 pages.

Huston, D.L. and Large, R.R.
1989: A chemical model for the concentration of gold in volcanogenic massive sulphide deposits. Ore Geology Review, Number 4, pages 171-200.

Kappel, E.S. and Franklin, J.S.
1989: Relationships between geological development of ridge crests and sulfide deposits in the northeast Pacific Ocean. Economic Geology, Volume 84, pages 485-505.

Swinden, H.S., Jenner, G.A., Kean, B.F. and Evans, D.T.W.
1989: Volcanic rock geochemistry as a guide for massive sulphide exploration in central Newfoundland. *In* Current Research. Newfoundland Department of Mines, Geological Survey of Newfoundland, Report 89-1, pages 201-219.

Tuach, J.
1976: Structural and stratigraphic setting of the Ming and other sulfide deposits in the Rambler area, Newfoundland. Unpublished M.Sc. thesis, Memorial University of Newfoundland, 128 pages.

Tuach, J., Dean, P.L., Swinden, H.S., O'Driscoll, C., Kean, B.F. and Evans, D.T.W.
1988: Gold mineralization in Newfoundland: A 1988 Review. *In* Current Research. Newfoundland Department of Mines, Mineral Development Division, Report 88-1, pages 279-306.

Tuach, J. and Kennedy, M.J.
1978: The geological setting of the Ming and other sulfide deposits, Consolidated Rambler Mines, northeast Newfoundland. Economic Geology, Volume 73, pages 192-206.

Wilton, D.H.C.
1989: Report on petrographic and Scanning Electron Microscope examination of polished sections from drillcore at the Main Mine orebody, Rambler Property, for MPH Consulting Ltd. Unpublished report, 16 pages.