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Article abstract

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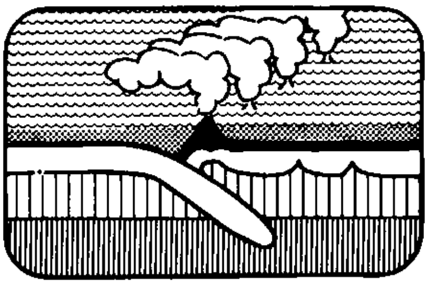

Plate Tectonic Setting of Newfoundland Mineral Deposits

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Summary
Newfoundland Paleozoic mineral deposits show many characteristics which allow for their classification in terms of distinct plate tectonic environments. The Lower Paleozoic deposits are mainly stratigraphically controlled, ranging from Mississippi Valley type zinc deposits, ophiolite, Cu, Cr and asbestos, Kuroko-type polymetallic Zn, Cu, Pb, Ag, Au, to shallow water manganese and oolitic hematite deposits. The upper Paleozoic deposits are mainly associated with Devonian granitoid intrusions (e.g., Cu-Mo and/or F deposits), with minor sedimentary Zn-Pb and Ba-Sr in intra-continental Carboniferous sediments. Other less important deposits likewise fit plate tectonic models.

Introduction
The plate tectonics or "new global tectonics" concept can be simply stated as follows (after Isacks *et al.*, 1968):

1. The outer earth can be divided into three layers, namely the rigid *lithosphere*, i.e., the crust and uppermost mantle to depths up to 100 km, the *asthenosphere*, with effectively no strength and extending to depths of several hundred kilometers, and the rigid *mesosphere*, the lower remaining portion of the mantle.

2. The lithosphere is divisible into a small number of thin blocks or plates which are in relative movement at their margins.

3. Plate margins, the principal zones of tectonic activity within the earth, can be described as *accreting* where plates separate and new crust is created at the ocean ridges, *consuming* where one plate is destroyed by underthrusting beneath another (at island arcs), and *transform faults* where one plate slides past another with a strike slip motion.

Two important extensions to this concept, although implied by previous authors and now generally taken for granted, should also be explicitly stated.

4. These tectonic zones or plate boundaries are characterized by unique assemblages of igneous, sedimentary and metamorphic rocks.

5. Certain types of economic mineral deposits are uniquely formed in specific plate regimes.

This last point is rapidly becoming recognized by economic geologists with regard to presently active plate regimes, but is less accepted for the pre-Mesozoic. The main concern of the present paper is to apply the concept to the Paleozoic mineral deposits of Newfoundland.

Metallogenic Aspects of Plate Tectonics
There are many problems to taking a strictly actualistic approach in applying plate tectonics to the remote geological past, such as the apparently unique nickel deposits of the Western Australian and Canadian Archean, or the vast copperbelt deposits of Central Africa (Watson, 1973). Nevertheless, the concept can be successfully applied as far back as the Lower Paleozoic, and the following discussions are partly based on the papers of Sillitoe (1972a, 1972b, 1972c), Guild (1971, 1972a, 1972b), Mitchell and Garson (1972), Sawkins (1972), and Mitchell and Bell (1973).

Accreting plate margins. Oceanic crust is created at ocean ridges by partial melting of the upper mantle (Kay *et al.*, 1972) with oceanic sediments being predominantly formed by chemical precipitation and pelagic limestone sedimentation. In some areas these chemical sediments are enriched in Cu, Fe, Mn, and other metals, the Red Sea Brines and sediments of the East Pacific Rise being the two best documented examples (Degens and Ross, 1969; Bostrom and Petersen, 1966).

Rocks formed at accreting plate margins are almost certainly represented by the older ophiolite terranes (Dewey and Bird, 1971; Coleman, 1971) and the overlying metalliferous sediments provide a model for formation of the characteristic massive sulphide deposits occurring in ophiolites. The deposits of the Troodos ophiolites of Cyprus are the best known of many documented examples (Searle, 1972; Sillitoe, 1972c; Constantinou, 1973) and such deposits are consequently often described as "Cyprus-type" deposits.

Along with the massive sulphide deposits, ophiolites also characteristically contain deposits of chromite (in peridotites, mainly dunite), nickel (in gabbro) and asbestos (in serpentinized peridotite). Chromium and nickel are almost certainly formed during ocean crust generation, but one cannot say whether the asbestos deposits are formed during alteration and deformation in the ocean basins (e.g., along transform faults), during emplacement, or during subsequent deformation. If either of the latter two, which would explain the lack of any asbestos reported from dredge hauls, then asbestos might be considered a product of consuming rather than accreting plate margins. The general features of deposits of accreting plate margins are shown in Figure 1 (after Searle, 1972; Malpas, 1973).

Consuming plate margins. Guild (1971, 1972a,b); Sawkins (1972); Pereira and Dixon (1971); Sillitoe (1972a, 1972b, 1972c) and Mitchell and Garson (1972) have all pointed out the general relation between porphyry copper deposits and consuming plate margins, and the latter three authors have been particularly successful in demonstrating a mineral zonation in granitoid rocks across Cordilleran-type subduction zones, as shown in Figure 2. Equally important, however, are the volcanogenic "Kuroko-type" massive sulfide deposits which occur in island arc environments (Fig. 3), and it should be noted that they are likewise unique to consuming plate margins. They are fundamentally different from the simple Cu-Fe-(Zn) Cyprus-type deposits in that they are polymetallic, containing Zn, Pb, Cu, Fe, Au and Ag, and they are commonly found in the late stage dacitic or andesitic volcanics of calc-alkaline island arc suites. As they are confined to the calc-alkaline suites, they would at least be related to position above subduction zones to the extent that they would occur in the central parts of island arcs according to Kuno's (1966) model and the intermediate stages of island arc construction according to the Jakes and White (1972) model. Besshi type deposits are considered by the present author as a sub-group of these.

The wide range of ore types formed at consuming plate margins, and especially their difference from the metalliferous sediments or Cyprus-type deposits, may be evidence against Sillitoe's (1972c) suggestion that anomalous crust be consumed in order to produce Kuroko-type or porphyry copper deposits. It is much more likely that these deposits are formed by efficient "distillation" processes from a variety of subducted source rocks, since they are grossly similar regardless of the material subducted. The apparent difference in Au:Mo ratios of porphyry copper and molybdenum deposits in Cordilleran and island arc environments reported by Kessler (1973) may be explained by the fact that larger volumes of continent-derived sediments are consumed in the former environment.

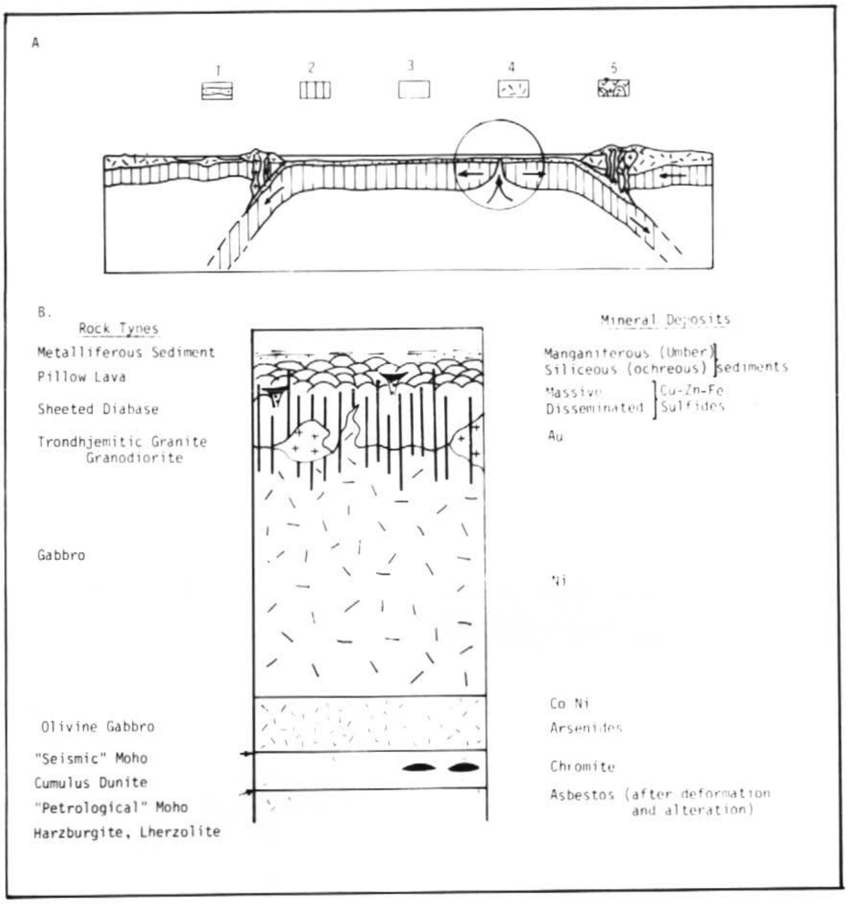


Figure 1
Mineral deposits of accreting plate margins.

A. An idealized model of different plate tectonic regimes based on a cross-section of the Pacific Ocean (after Dewey and Bird, 1971). 1 – oceanic crust; 2 – lithosphere; 3 – asthenosphere; 4 – continental crust; 5 – intrusive and extrusive igneous rocks produced above subduction zones. The circled region is expanded in Fig. B.

B. An idealized cross-section through the oceanic crust based on ophiolite models (after Moores and Vine, 1971; Church, 1972; Malpas, 1973) with stratigraphic location of mineral deposits (after Searle, 1972).

Transform fault margins. It is unlikely that transform faults in themselves can be directly responsible for ore formation unless they are "leaky", i.e., there is some magmatic or hydrothermal activity taking place along them. A possible example of this is the Gulf of California, where metalliferous brines of the Salton Sea are forming (White, 1968), although these brines might equally be the result of activity along short segments of the East Pacific Rise which passes through the area.

Transform faults may be more important in producing secondary ore deposits by deformation and alteration of oceanic crust. For example, asbestos might be produced by alteration of peridotite, or sulfides might be concentrated by shearing, mechanical remobilization, and leaching. However, there is no direct evidence for these processes.

Intra-plate regions. A particular plate may contain a variety of metallogenic environments which show no relation to the tectonic processes taking place at its margin. For example the America Plate contains the full range of geological environments from ocean deeps through Atlantic-type continental margins to the high Cordillera.

The ferromanganese nodules and encrustations from the ocean floors are probably the most widely distributed deposits which are independent of plate boundary tectonics. They are most wide-spread in the North Pacific and in other areas which are protected from sedimentation of continental and biogenic debris (Fig. 4, after Horn

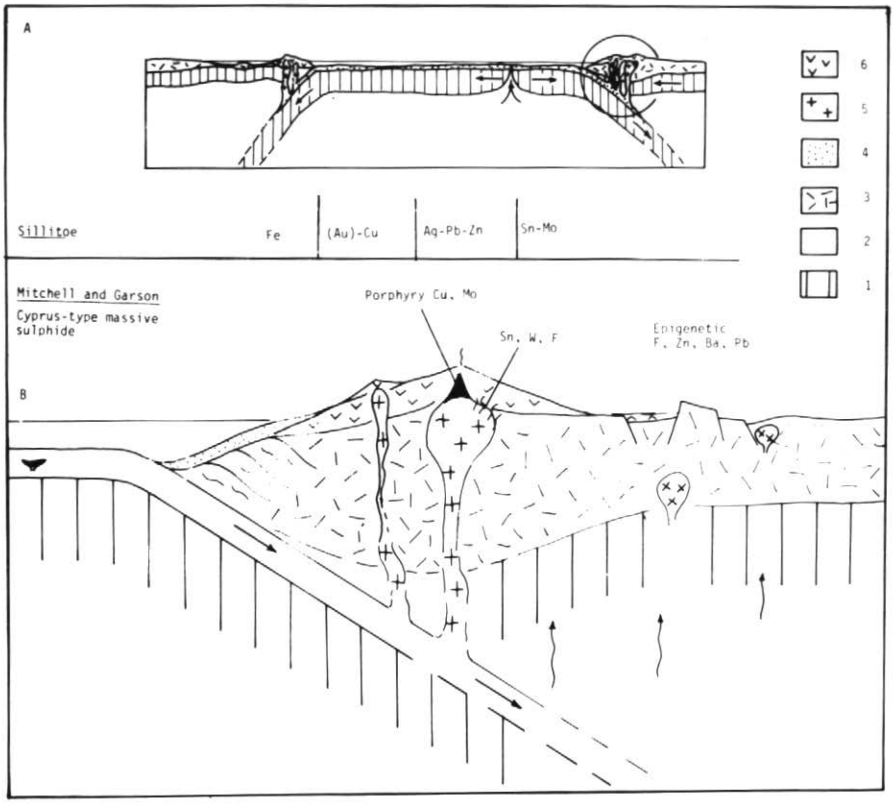


Figure 2
Mineral deposits of Cordilleran type consuming plate margins.

A. As for figure 1A.

B. Zonal distribution of mineral deposits across subduction zones according to Sillitoe (1972a) and Mitchell and Garson (1972). 1 – upper mantle; 2 – oceanic crust; 3 – continental crust; 4 – clastic sediments; 5 – granitoid intrusives; 6 – volcanic rocks.

et al., 1972). They are variably enriched in Ni, Cu, Co, Ti, Pb, V, Ag, As, Zn, U and Mo depending upon both proximity to potential magmatic sources, the environment of deposition and redox potential in particular (Cronan, 1972). In some cases they are rich in heavy metals, e.g., the Bauer Basin (Dymond *et al.*, 1973). The widespread nature of these deposits makes it difficult to predict any particular criteria by which ancient deposits might be found, and it is surprising that more such deposits are not found in areas of ancient oceanic crust. One explanation may be the diagenetic remobilization of Mn as evidenced by its rapid decrease with depth and virtual absence below 50 cm. in modern sediments. Some ancient ferromanganese deposits appear to be of a metal-poor type formed in fresh water lakes and intertidal zones.

Lead-zinc deposits of the Mississippi Valley type are the second most valuable group of intra-plate deposits being mined today, making up over 11 per cent of the world's total Pb and Zn (Laznicka and Wilson, 1972). There is a vast literature describing such deposits (e.g., Brown, 1970) and the generalization can be made that they are associated with limestones around the margins of intra-cratonic basins, probably resulting from outward migration of hypersaline connate waters (Dunham, 1973). In many areas of North America they are associated with Precambrian basement highs, possibly around faults of regional significance produced by earlier plate adjustment and break-up (Russell, 1971).

The Atlantic type continental margins with thick sediments accumulations will almost certainly prove to be most important for sources of petroleum, as exemplified by the North Sea oil fields, and as reflected in the intense exploration on the continental shelf of eastern North America (Sherwin, 1972). They are also important areas of accumulation of phosphate deposits, in particular off the west coast of Africa (Tooms and Summerhayes, 1968). It is possible that the vast stratabound copper deposits of the Zambian copper belt and the stratabound pyrite zinc-lead deposits of Rammelsberg and Mount Isa, together accounting for more than 29 per cent of the world's total Cu-Pb-Zn (Laznicka and Wilson, 1972) are produced by diagenetic processes in such environments, although it is more likely that at least the Rammelsberg deposits were associated with volcanic activity (Krebs, 1973), and Burke and Dewey. (1973) consider them as forming within aulacogens.

There are numerous other types of intra-plate deposits apparently resulting from processes other than plate tectonics, for example stratiform mafic intrusions (Bushveld), meteorite impact craters (Sudbury), titanium in anorthosites (Quebec), kimberlitic and carbonatitic intrusions (Africa) coal deposits, etc. These have to be recognized on criteria other than those under discussion in this paper.

Marginal basins and inter-arc basins. These areas are poorly understood in terms of mineral deposits, but the characteristic features such as high heat flow, volcanic activity, nearness to a variety of sedimentary sources, and a variety of depositional environments may make them highly favourable areas for base metal deposition. The generation of marginal basin crust may be a fundamentally different process from that on the mid-ocean ridges in that water in subducted oceanic crust would be involved in hydration and partial melting of the upper mantle (Karig, 1971; Green and Ringwood, 1967). As there appears to be some correlation between the PH_2O or PO_2 and the presence of Cr (high PO_2) or Ni (low PO_2) deposits (Challis, 1971), this may explain why some ophiolites have one element dominant over the other – i.e., ophiolites of marginal basin crust might be more favourable for Cr deposits than those of true ocean basins. Criteria for possible

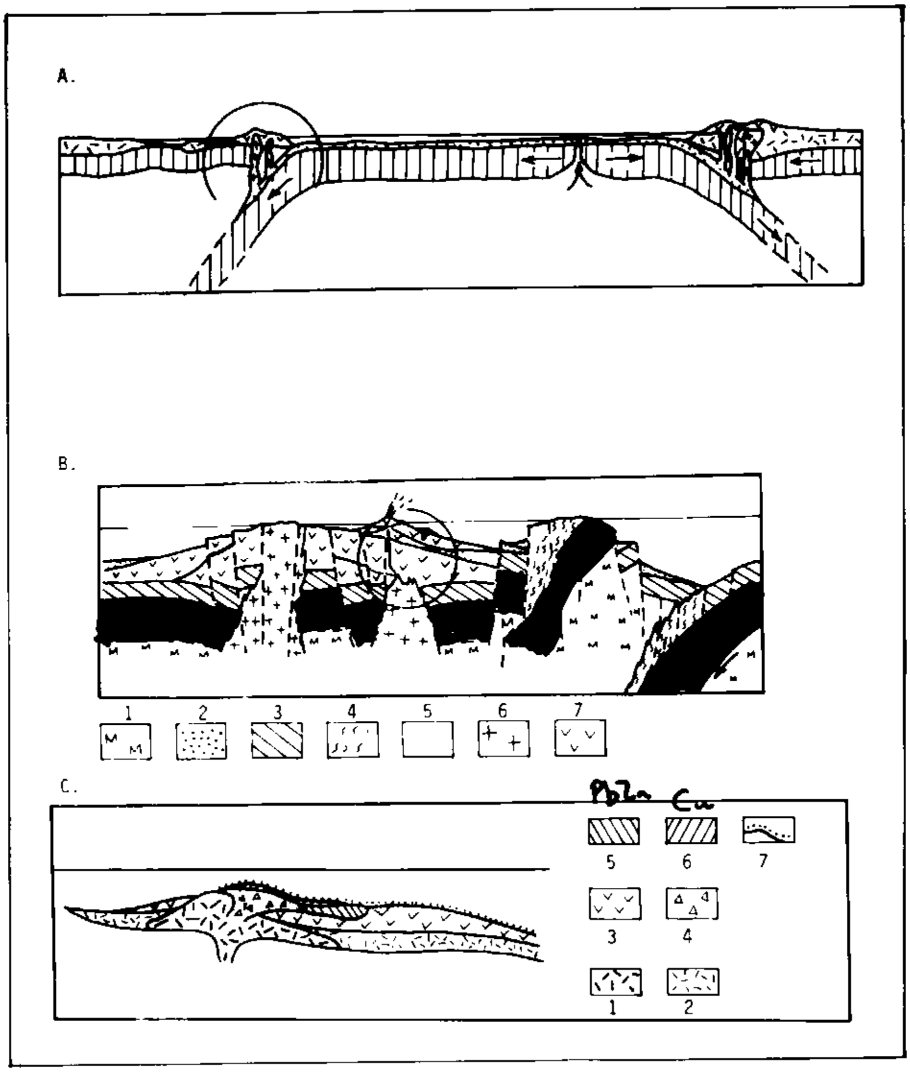


Figure 3
Geological setting of island arc (Kuroko-type) massive sulphide deposits.

A. As for Figure 1A.

B. Generalized island arc model (after Mitchell and Reading, 1971). 1 – upper mantle; 2 – oceanic layer 3: gabbro and sheeted diabase; 3 – oceanic layer 2: tholeiitic pillow lavas; 4 – melange deposits and amphibolites; 5 – volcanic turbidites; 6 – granitoid intrusives; 7 – calc-alkaline volcanic rocks.

C. Typical Kuroko deposits (after Horikoshi, 1969). 1 – dacite lava dome; 2 – andesitic lava; 3 – explosion breccia; 4 – siliceous ore (py); 5 – black ore (Zn, Pb, Cu); 6 – yellow ore (Cu-py); 7 – barite, chert, gypsum.

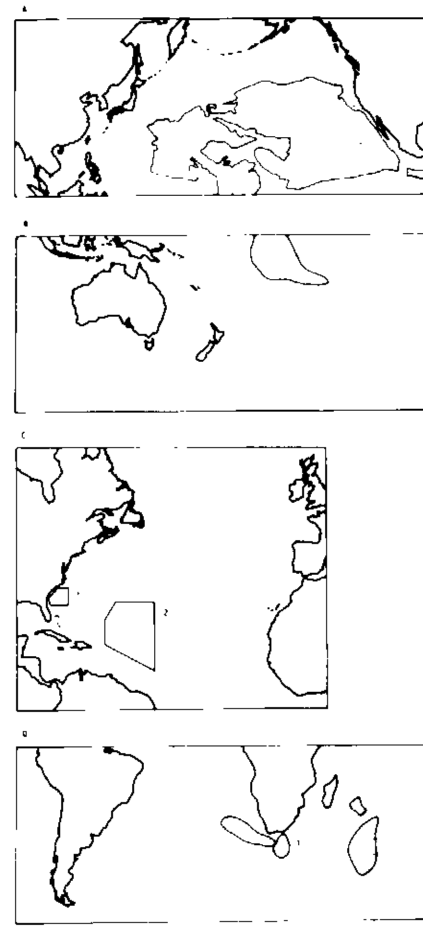


Figure 4
World-wide distribution of ferromanganese deposits shown by striped areas (after Horn et al., *1972).*

A. North Pacific – Limits of deposits are defined by relative dilution rates from land-derived sediments or, in the south, from rapidly accumulated biogenic carbonate, the highest density of nodules being between 6° 30′ N and 20° N.

B. South Pacific – deposits are concentrated along the topographic highs of linear archepelagos.

C. North Atlantic – deposits are restricted to areas of non-deposition of detrital sediments on the current-swept Blake Plateau (1) and the Red Clay province (2).

D. South Atlantic and Western Indian Ocean – deposits occur in basins protected from continental and biogenic debris or on the current-swept Agulhas Plateau (1).

recognition of the respective ophiolite types are given by Dewey and Bird (1971).

Geology and Mineral Deposits of Newfoundland

The island of Newfoundland is divisible into three main tectonic zones, namely stable Precambrian-Paleozoic platforms on the east and west and a "mobile" or "eugeosynolinal" zone in the centre (Williams, 1964). These three zones are further divisible into eight subzones on the basis of difference in stratigraphy and structural styles (Williams *et al.*, 1972). These tectono-stratigraphic divisions and associated mineral deposits are outlined in Figure 5, and the following discussion will summarize the main features of these zones within the context of plate tectonic models. More detailed geological descriptions and references are given by Fogwill (1970), Williams *et al.* (1972), and Strong (1974b).

Precambrian. The Western Platform (Fig. 5) is dominated by an elongate block of Grenville basement making up the Long Range Mountains, and smaller areas of Grenville basement found in the Indian Head Range in the southern part of zone A. The only reliably documented example of Precambrian rocks in the central mobile belt is the gneissic basement to the Fleur de Lys rocks of the Burlington Peninsula recently discovered by M.F. DeWit (personal communication, 1972). Other areas of amphibolite and granitic Precambrian rocks have been suggested in Notre Dame Bay (Bird and Dewey, 1970; Kennedy and DeGrace, 1972) but these have also been interpreted to have younger origins (Kean, 1973; Strong and Payne, 1973). Precambrian gneissic basement is found in the "Gander Lake" metamorphic belt (subzone "G", Fig. 5) which marks the boundary between the Central Mobile Belt and the western parts of the Avalon platform (Kennedy and McGonigal, 1972). The only mineral deposits recognized as Pre-Hadrynian are the anorthosite-ilmenite occurrences in the Indian Head Range, and as these are not related to Paleozoic plate tectonics, they are not discussed further.

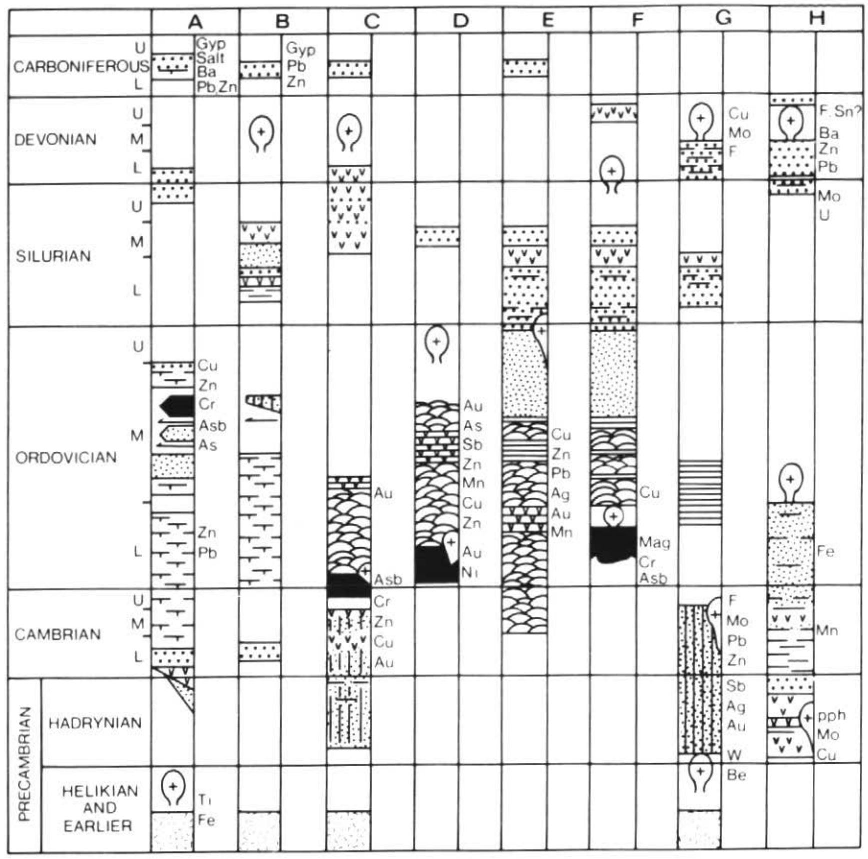
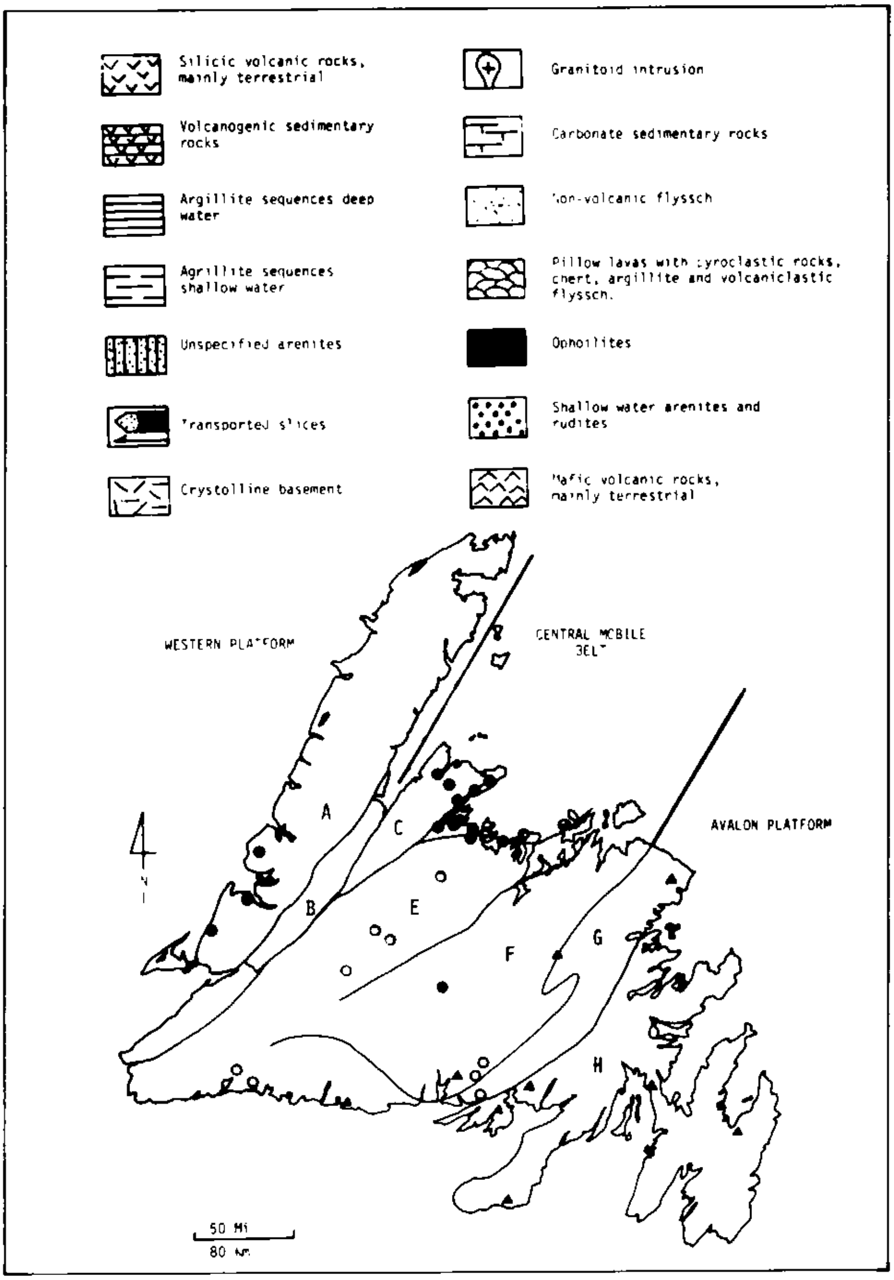


Figure 5
Tectono-stratigraphic zones of Newfoundland (after Williams et al., 1972) *and main mineral occurrences (after Fogwill, 1970).*

Late Hadrynian. The late Hadrynian (Fig. 6A) was a period of extension and thinning of the older continental crust. This resulted in extrusion of tholeiitic to transitional plateau lavas (Williams and Stevens, 1969; Strong and Williams, 1971; Strong, 1974) along north-trending fissures presently marked by diabase dyke swarms (Zone A), with thick wedges of clastic sediments deposited on the continental margins (Zones C and G). Syntectonic Be- and Mo-bearing granitoid rocks intrude these sediments and their underlying basement in Zone G. The Avalon Platform is dominated by large volumes of Late Hadrynian volcanic rocks, primarily a bimodal basalt-rhyolite assemblage with volcanically derived sediments, which were interpreted by Huges and Brueckner (1971) as an island arc assemblage, and by Papezik (1970) and Schenk (1971) as produced in a rifting environment. Strong *et al.*, (1973a, 1974b) drew an analogy between the Avalon and Gander Lake Belt and Cordilleran type continental margins, so as to explain the gneissic and granitoid rocks of the Gander Lake Belt, with the bimodal volcanic assemblage forming in a Basin and Range type of environment to the east. Minor Cu and Mo occurrences are found on the Avalon Platform within the Holyrood granite, which also produced economic pyrophyllite deposits around its margins. The Pb, Zn, Ag, Sb occurrences of Zone G are insufficiently known to say whether they have a syngenetic or hydrothermal origin. Any oceanic crust produced at this time was either destroyed by subduction or has not yet been recognized.

Cambrian. The Cambrian of the Western Platform (Fig. 6B) commences with arkosic sediments in Northern Newfoundland, succeeded by eastward-thickening Cambrian to Lower Ordovician limestone and dolomites, orthoquartzites and shales, reflecting relatively stable shallow water deposition. Some silicic volcanic rocks, such as the Cape St. John Group of Zone C, may suggest that some island arc volcanism was taking place at this time. There is little evidence as to the direction of dip of any subduction zone, and two alternative hypotheses have predominated. Church and Stevens (1971) suggest that in the Lower Ordovician a southeast-dipping subduction zone is necessary to permit emplacement (westward obduction) of the ophiolites of west Newfoundland. It is possible that such a situation prevailed earlier on in the Cambrian, accounting for the Cape St. John Group, as suggested in Fig. 6B. Dewey and Bird (1971) and Kennedy (1973) suggest that a Cambrian marginal ocean basin existed in Zone C, and that the Cu, asbestos (asb) and Cr deposits of Zone C were formed in this marginal



basin, according to a model approximately as shown in Figure 6C. The Rambler Cu-Fe-Zn-Au-Pb deposits show conflicting evidence of both Cyprus-type (Gale, 1973) and Kuroko-type origin, and require further study before they can be reliably characterized.

The eastern margins of the Central Mobile Belt (Zone G) was characterized by a period of sedimentation in the early Cambrian and deformation and granitic intrusion in the late Cambrian (the microcline-megacrystic Deadman's Bay pluton has a zircon age of about 510 m.y. (R. Naylor, personal communication). It is not understood whether the sediments are trench deposits (Fig. 6A) or were formed at a more stable Atlantic-type continental margin (Fig. 6B). The former is preferred by the present author, and it is considered that the Hadrynian Cordilleran-type margin prevailed there in the Cambrian and possibly even into the Devonian (Strong *et al.*, 1973, 1974). If eastward subduction is not postulated than the tectonic and intrusive might possibly be explained by subduction of an oceanic ridge (Fig. 6C), as suggested for western North America by Kistler *et al.*, (1971).

The Cambrian of the Central Mobile Belt is represented by few fossiliferous rocks (e.g., Kay and Eldridge, 1968), and some of the ore-bearing rocks from there could represent anything from Cambrian to Ordovician in age. These rocks are mostly mafic pillow lavas and volcaniclastic sediments with minor limestone lenses. The lowermost rocks contain sheeted dykes and are chemically similar to ocean-ridge basalts and are thus interpreted as representative of oceanic crust (Upadhyay *et al.*, 1971; Smitheringale, 1972; Strong, 1972). These contain the typical Cyprus-type pyrite-chalcopyrite deposits such as Betts Cove, Tilt Cove, Whalesback, and Little Bay (Upadhyay and Strong, 1973). The allochthonous Bay of Islands ophiolites, transported westward during the Lower Middle Ordovician (Stevens, 1970), are thought to have been derived from this Central Newfoundland oceanic terrain. Stukas and Reynolds (1974) obtain an $^{40}Ar/^{39}Ar$ age of 492 ± 5 m.y. for gabbro associated with the Pilleys Island sheeted dykes, which accords with K/Ar ages obtained for other Newfoundland ophiolites by Archibald (personal communication, 1973). The west Newfoundland ophiolites likewise contain typical Cyprus-type deposits (e.g., York Harbour) as well as chromite and asbestos.

The Cambrian of the Avalon Platform commences with deposition of the orthoquartzites of the Random Formation, now being quarried for silica. These are overlain by Cambrian shales and minor limestones containing algal structures which suggest a shallow water origin. Low-grade manganese deposits occur within these shales, being most important in the Middle Cambrian. Minor alkali basaltic volcanism occurred in the Cambrian of the Avalon platform, but no mineral deposits are associated with it.

Ordovician. The Ordovician was marked by continued deposition of reef limestones on the Western Platform, oceanic and island arc volcanism in the Central Mobile Belt, and clastic sedimentation on the Avalon Platform, with ophiolite obduction (Zone A) and deformation on the western (Zones C and D)

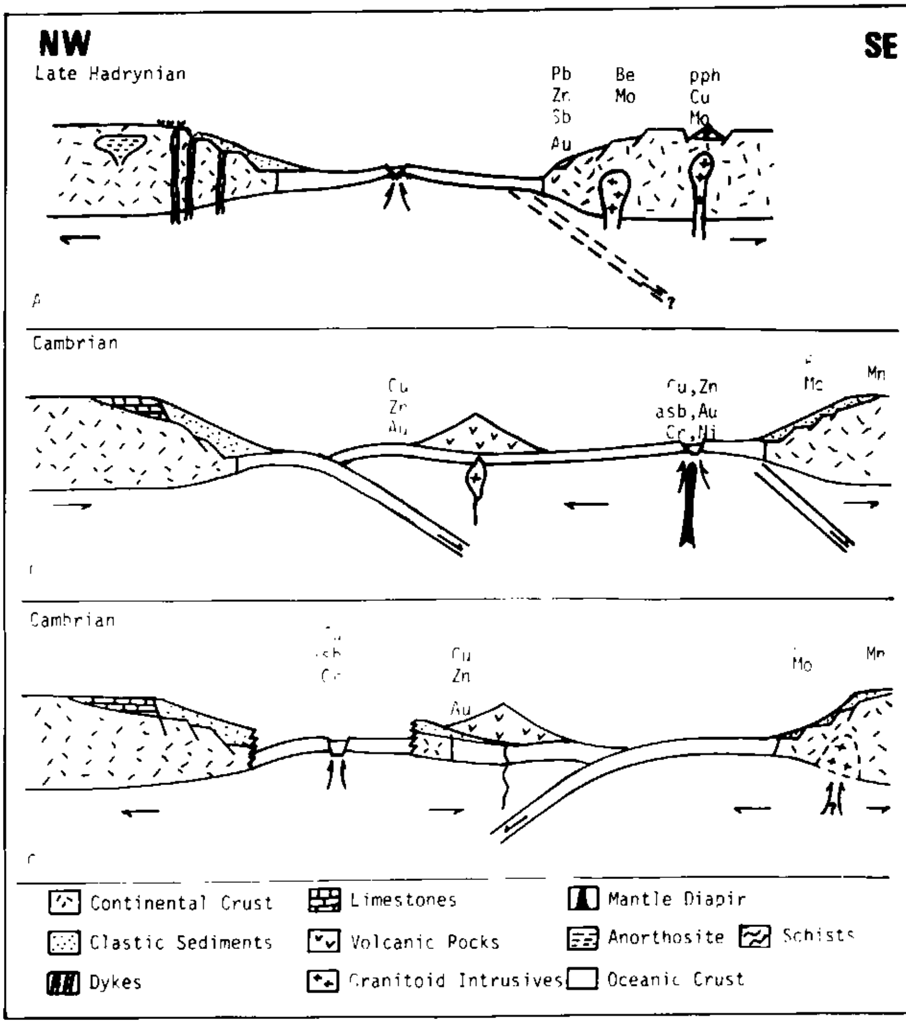


Figure 6
Plate tectonic models for Newfoundland in the late Hadrynian (A) and the Cambrian compatible with models proposed by Church and Stevens (1971) (B) or Dewey and Bird (1971) and Kennedy (1973) (C). Symbols as for Figure 7.

margins of the Central Mobile Belt. As described for Figure 6, there is no conclusive evidence for direction of dip of any possible subduction zone, and it could have been as shown in either Figure 7A (after Dewey and Bird, 1971 and Kennedy, 1973) or Figure 7B (after Church and Stevens, 1971) but the latter is preferred. Although the eastern margin of the mobile belt is poorly understood, Ordovician melange deposits in Zones E and F (Kay, 1972; Kennedy and McGonigal, 1972) suggest the existence of a trench at this time. The intrusive nature of some of the Gander Lake ultramafic bodies led Stevens *et al.* (1974) to interpret them as mantle diapirs rising from an eastward-dipping subduction zone, and Malpas and Strong (1974) found the chromite of these bodies to have consistently higher Cr:Al ratios than those in the low-pressure cumulus dunites of the Bay of Islands ophiolites.

The Mississippi-Valley type Zn deposits, best known in the Daniel's Harbour area, occur within the Lower Ordovician parts of the Zone A limestone sequence, in the St. George Formation at a karstic unconformity with the Middle Ordovician Table Head Formation (Collins and Smith, 1972). In the Central Mobile Belt the ophiolitic rocks are generally overlain by a thick sequence of pillow lavas, pyroclastics, and volcanic flysch which are interpreted as island arc deposits (Kean, 1973; Strong and Payne, 1973). They contain a variety of polymetallic deposits ranging from the Cu-As-Sb-Au deposits of the Moreton's Harbour Area (Gibbons and Papezik, 1970; Strong and Payne, 1973) to the typical Kuroko-type Cu-Zn-Pb-Ag deposits of Pilleys Island (Strong and Peters, 1972; Strong, 1973). The large Buchans deposits also fit within this latter category (Thurlow, 1974) although there is some doubt as to whether the Buchans deposits are Ordovician or Silurian in age.

The Cambrian sediments of the Avalon Platform are conformably overlain by thicker and sandier Lower Ordovician rocks containing the oolitic hematite beds which were mined on Bell Island in Conception Bay.

Silurian. The Silurian was a time of shallow marine to predominantly redbed alluvial fan type sedimentation, with minor mainly subaerial volcanism, throughout the central and western parts of Newfoundland, with no post-Ordovician record being left on the Avalon platform. This represents the period when ocean basins of the Central Mobile Belt were closing and consolidating. The red sandstones and acid volcanics of the Micmac Formation on the Burlington Peninsula, the Springdale Group in the western Central Mobile Belt (Zone E), and the Botwood Group of the eastern Central Mobile Belt (Zone E) are the best examples of these rocks. There are no important mineral deposits within these rocks unless, as mentioned above, the Buchans and Pilleys Island Kuroko-type deposits are of Silurian age.

Some of the Newfoundland granitoid rocks are of Silurian age but no mineral deposits are known for these rocks.

Devonian. The Devonian period (Fig. 7C) is represented by redbeds on the Western Platform and only minor intrusive bodies on the eastern parts of the Avalon Platform, but in the Central Mobile Belt and the Gander Lake Belt (Zone G) was a period of extensive granitoid intrusive activity. The only extrusive Devonian igneous rocks in Newfoundland are in a small area of rhyolite flows in the centre and southwest of the island, and these are not known to be mineralized.

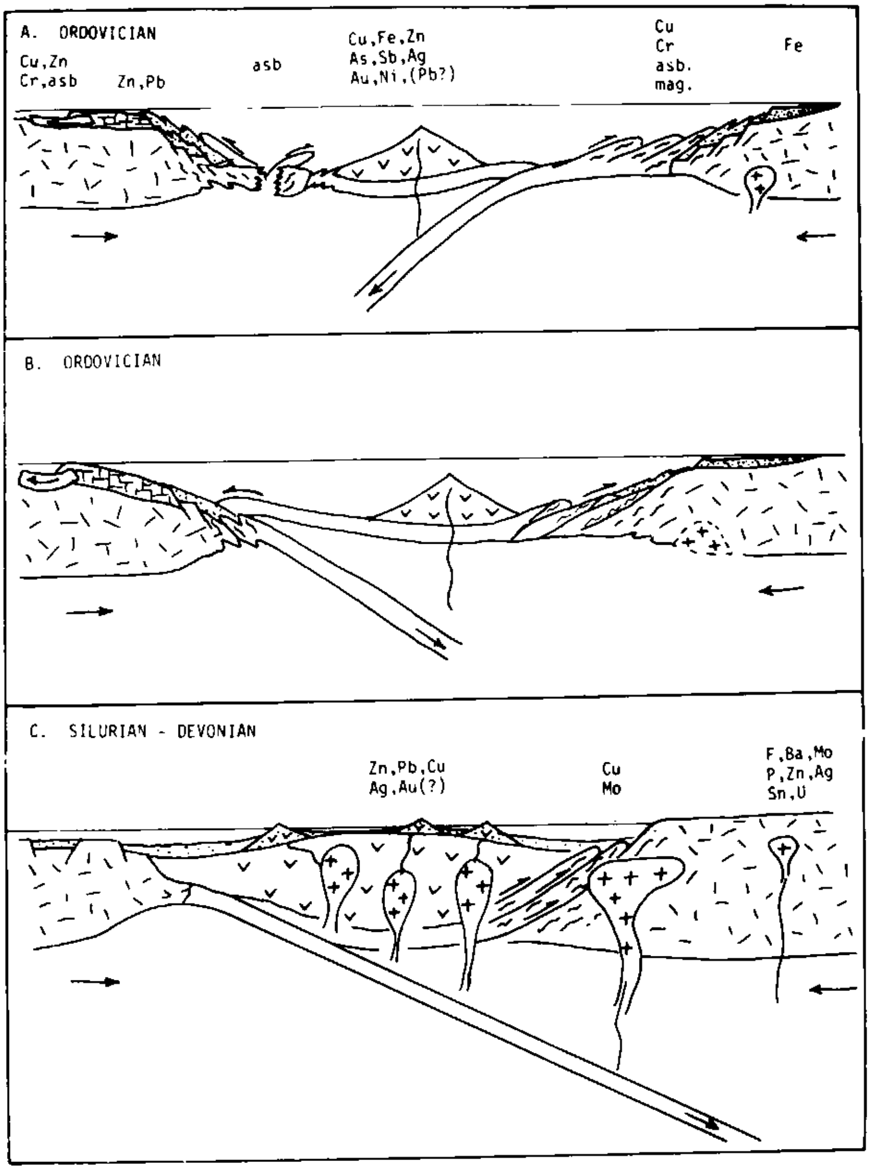


Figure 7
Plate tectonic models for Newfoundland in the Ordovician after Dewey and Bird (1971) and Kennedy (1973) (A), or Church and Stevens (1971) (B), and in the Silurian and Devonian (C).

The Devonian granitoid bodies represent a number of types, ranging from calc-alkaline zoned plutons in the Central Mobile Belt (e.g., Mount Peyton and Hodges Hill), microcline-megacrystic granites – quartz monzonites common to the Gander Lake Belt (e.g., the Ackley City Batholith), and the granites *sensu stricto* which occur as small discordant plutons east of the Gander Lake Belt on the Avalon Platform (e.g., St. Lawrence). It emphasized that the Devonian age of many of these plutons is in doubt, and the reader is referred to Strong *et al.* (1973a) for further discussion.

Copper and molybdenum mineralization is common in the quartz monzonite plutons of the Gander Lake Belt in Fortune Bay, while fluorite (with minor Ba-Sn-Zn-Pb mineralization) is found in the discordant plutons of the Avalon platform, the large deposits long mined at St. Lawrence being the best examples. This eastward variation in type of granitoid mineralization is reminiscent of the zoning described by Mitchell and Garson (1972) for Southeast Asia. Although little base metal exploration has been done in the granitic terrains of Newfoundland, and such interpretations of metal zoning are hence very tentative, this pattern does coincide with an eastward increase in K_2O of the granitoid rocks (Strong *et al.*, 1973, 1974).

Carboniferous. The Carboniferous period (Fig. 8) is represented in Newfoundland by two sedimentary basins in the western part of the island, filled with shallow water conglomerates and sandstones, with minor limestones and evaporites. The evaporites are being quarried for anhydrite and gypsum at Flat Bay and are now being investigated for barite potential (McArthur, 1973). The presence of Pb-Zn mineralization in the Port au Port area, which is similar to that in the Carboniferous rocks both to the north and south, e.g., the Walton deposits of Nova Scotia and the Carboniferous of Ireland, lends some hope that base metal deposits might be found in the Newfoundland Carboniferous (Russel, 1971).

The only post-Carboniferous rocks in Newfoundland are lamprophyre dykes (Triassic to Jurassic) and Pleistocene glacial deposits.

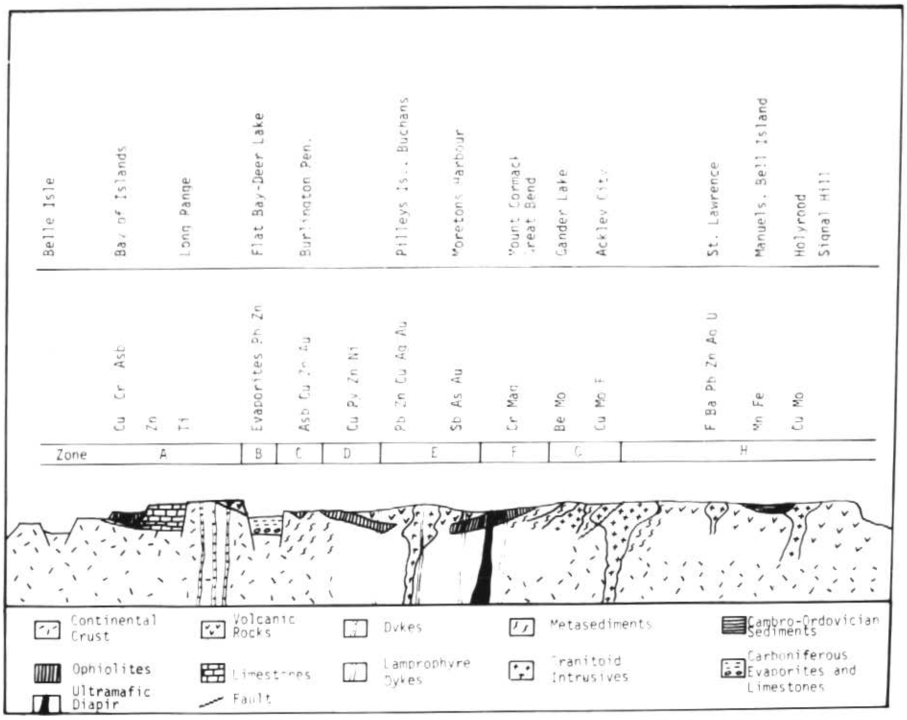


Figure 8
Schematic cross-section across Newfoundland showing the distribution of mineral rights.

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