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Article abstract

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Mineralization Related to Post-Acadian Tectonism in Southern New Brunswick

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Summary
The formation of post-Acadian mineral deposits in southern New Brunswick is correlated with a distinct sequence of tectonic events. A great variety of epigenetic deposits occur within and along the contacts of Middle Devonian to Early Carboniferous igneous intrusions and associated sub-volcanic stocks, that were emplaced in a succession of distensional structures.

The host rocks of the stratiform deposits generally reflect formation contemporaneous with gentle epeirogenic movements. The intervening strata reflect episodes of intense faulting and folding. Climatic conditions associated with the formation of different stratiform deposits varied from arid to humid.

Introduction
The long and complex tectonic history in southern New Brunswick has given rise to a great variety of mineral deposits. Precambrian and Silurian stratiform base metal sulphide deposits were intensely deformed, and in part remobilized, during the Early-Middle Devonian (Acadian orogeny) and/or Early Carboniferous deformations (Ruitenberg, 1972; Ruitenberg *et al.*, 1972).

Numerous deposits formed as a result of post-Acadian tectonic activity and include both epigenetic and stratiform deposits (Figs. 1A and 1B, and Table I).

Tungsten-molybdenum-bismuth and tin base metal sulphides occur in Lower Carboniferous felsic subvolcanic stocks. Antimony sulphides were concentrated along major fracture zones that probably formed during Early Carboniferous time. Uraniferous volcanogenic sedimentary rocks are locally interbedded with Lower Carboniferous pyroclastics. Tungsten-molybdenum, molybdenum-copper and base metal sulphides occur also as veins and disseminations in Upper Devonian-Lower Carboniferous granitoid intrusions.

Oil and oil shale occur in a Mississippian sandstone and shale sequence that formed in lacustrine or lagoonal marine environments. High-grade limestone, gypsum, salt and potash, and locally base metal sulphides were deposited during Mississippian time, associated with marine transgression and regression. Copper and copper-uranium deposits occur in red and grey carbonaceous sandstone-shale sequences. Coal formed in Pennsylvanian clastic sedimentary rocks, that reflect a limnic depositional environment.

Post-Acadian Tectonic Evolution
Intense polyphase deformation, referred to as the Acadian orogeny, was terminated in southwestern New Brunswick with the emplacement of a granitic complex, ranging in age from Middle-Devonian to Early Carboniferous (Ruitenberg, 1967). Ordovician to Lower Devonian rocks and the northwestern margin of the Upper Precambrian belt have been affected by the Acadian orogeny; the dominant northeasterly structural trend reflects northwest to southeast shortening (Ruitenberg, 1967, 1968; Brown and Helmstaedt, 1970).

It is possible that rotational strain became important, in part of this deformed belt, during the final stages of the Acadian deformation. Trends of fold axes, and dextral offset on the northeasterly trending Belleisle fault, as suggested by Webb (1969), with sinistral offset along northwest trending subsidary faults appear consistent with effects of clockwise rotational strain, similar to that described by Wilcox *et al.* (1973). A major thrust fault in southwestern New Brunswick may also have been initiated during the waning stages of this orogeny.

Acadian structures were in part deformed and/or reactivated as a result of post-Acadian deformation. The penetrative cleavage was deformed by steeply plunging cross-folds that reflect northeast or east-northeast shortening (and northwest extension) (Ruitenberg, 1967, 1968, 1972). These structures are mainly concentrated along prominent northwesterly trending wrench fault zones, where northwesterly extension most easily occurred.

Ruitenberg (1967) demonstrated that this cross folding was contemporaneous with emplacement of the Middle Devonian to Lower Carboniferous (Post-Acadian) granitic complex in southwestern New Brunswick. The oldest rocks in this complex are medium- and coarse-grained biotite and biotite-hornblende granite, whereas the youngest consists mainly of porphyritic micro-granite or adamellite. Post-Acadian emplacement of these intrusions is confirmed by the fact that the associated contact metamorphism (biotite, sillimanite and orthoclase) is superimposed on the penetrative cleavage. Small plutons north of the main granitic complex are preferentially emplaced in northwesterly trending fault zones (where the cross-folds are concentrated), and in places have been sheared by later movements along these faults (Ruitenberg and Ludman, 1976). These satellite plutons are of similar composition and probably coeval with the late phase of the granitic complex (Fig. A).

East-northeast trending extensional fractures occupied by greisen veins, in the granite complex, are consistent with the regional strain associated with emplacement of the intrusive complex. Outside the granite several east to east-northeast trending fractures have a right lateral strike-slip component but this is probably a late movement (Fig. 1A, Table I). The origin of north-northwesterly trending extensional fractures locally superimposed upon the Acadian deformed rocks and the granitic complex is not certain. These fracture zones generally occur, however, in the vicinity of major northeast trending faults and may be related to lateral slip along these structures.

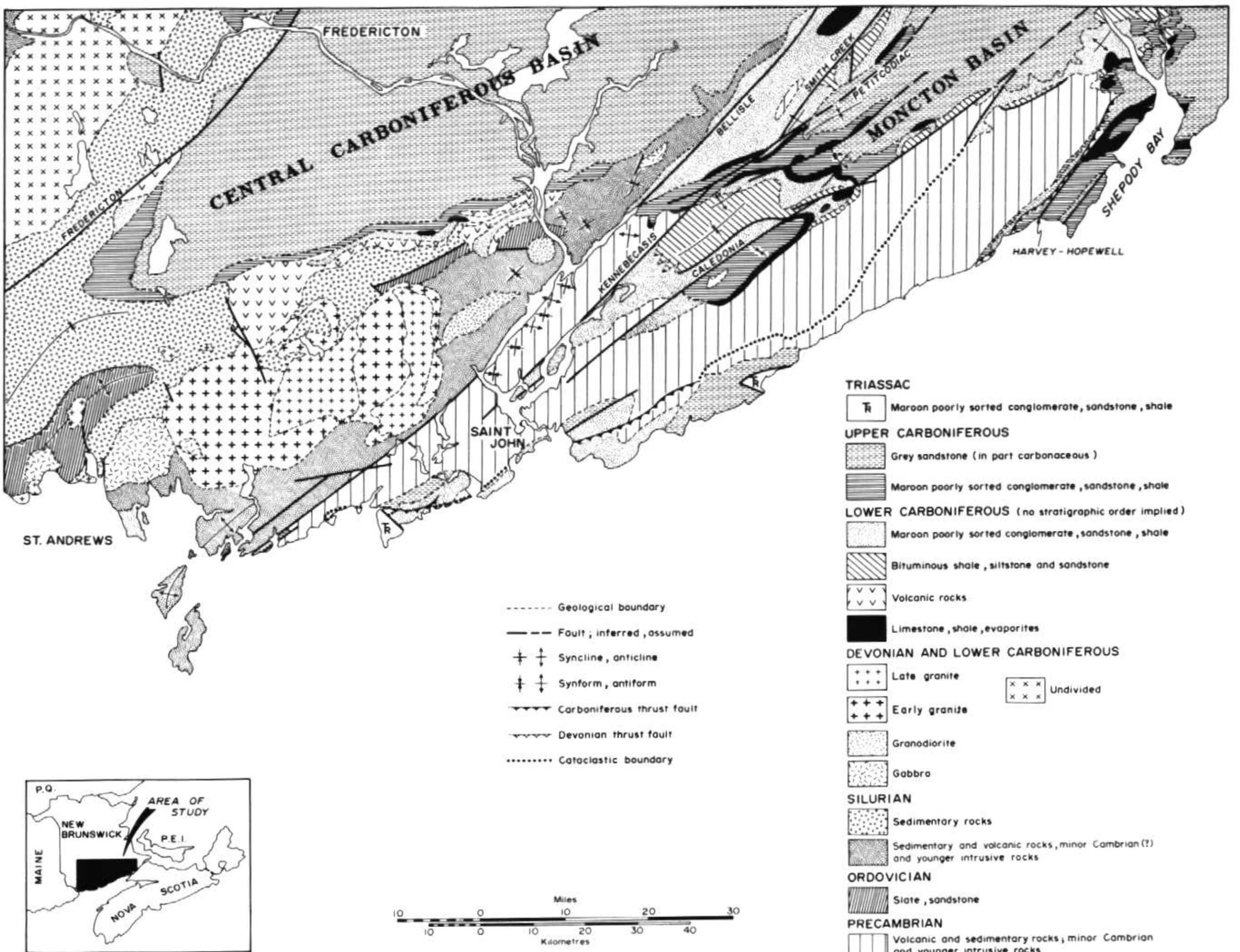

Figure 1A
General geology southern New Brunswick.

Subsequent deformational effects superimposed upon the deformed Paleozoic rocks and the granitoid bodies are highly complex. Block faulting and right-handed lateral slip along northwest trending faults appear to have prevailed along the northern margin of the granitic complex. Closely spaced faults of this type are associated with the formation of a Lower Carboniferous volcanic rift zone at Mount Pleasant (Ruitenberg, 1967).

Deformational effects associated with the successor basins are not fully understood and the interpretation indicated by Table I is tentative. The succession of sedimentary facies (Fig. 4) and deformational features however, suggest alternating episodes of intense block and wrench faulting, with associated folding, followed by more gentle epeirogenic movements. Relative displacements along most major faults remain to be determined. displacements along most major faults remain to be determined.

Intense tectonic activity coincided with deposition of coarse fluviatile clastic sediments containing abundant, highly deformed, Upper Precambrian volcanic fragments. Intense folding of Carboniferous rocks has only occurred in parts of the Moncton basin, whereas the Central Carboniferous basin is only weakly deformed.

The upper Devonian-Lower Carboniferous Memramcook Formation (Table I, Fig. 4), composed of poorly sorted, coarse, maroon clastics, probably was deposited during an episode of block faulting, that post-dated the penetrative deformation in the northeastern part of the "Fundy Cataclastic Zone" (Ruitenberg *et al.*, 1973).

The bituminous shale and sandstone of the Albert Formation possibly reflect a lacustrine (Greiner, 1962; van de Poll, 1972) or lagoonal marine environment (J. Worth, oral commun., 1976). The latter interpretation is suggested by the presence of minor interbedded limestone and salt. The Albert Formation, in part, probably represents the more distal facies of the Memramcook Formation.

Red and locally grey-green, poorly sorted sandstone and conglomerate of the Moncton Formation overlie the Albert Formation. Minor volcanic ash beds are locally associated with this formation and are probably coeval with volcanic rocks of the Piskahegan Group, deposited in the Mount Pleasant area. The coarse clastics and volcanic rocks of the Piskahegan Group represent the first deposition in the Central Carboniferous Basin (van de Poll, 1972). The Moncton Formation probably reflects renewed block faulting, and possible wrench faulting, accompanied by folding, as indicated by a local angular unconformity that separates the Albert and Moncton Formations (Gussow, 1953) in the northeastern part of the map area. This suggests that

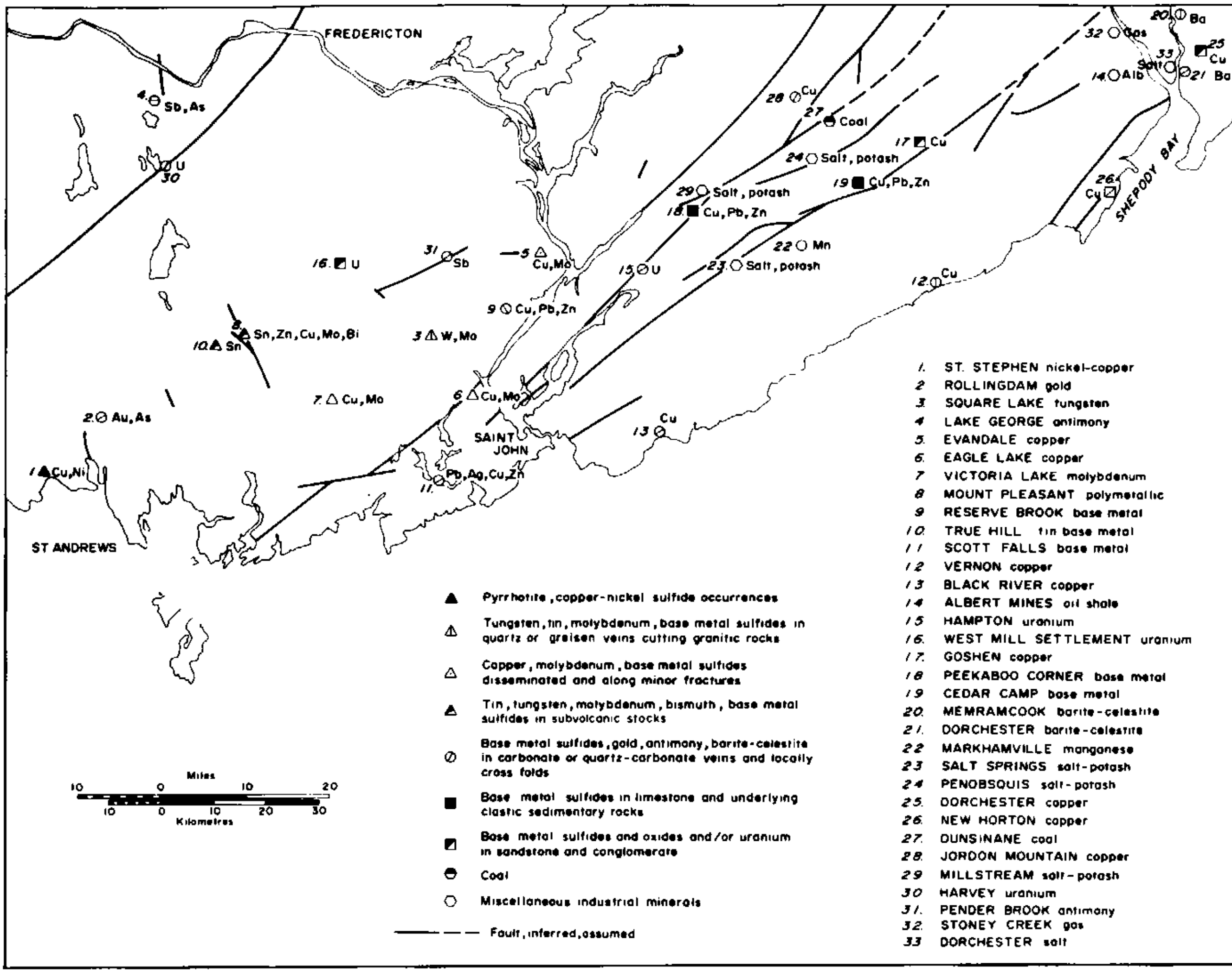

Figure 1B
Post-Acadian mineral deposits in southern New Brunswick.

deformation at this time was most intense along the leading edge of the Upper Precambrian basement, and possibly resulted from lateral movement of the Precambrian fault block.

The Moncton Formation grades upwards into a carbonate-evaporite sequence known as the Windsor Group, which mainly marks an episode of gentle epeirogenic movements resulting in a major transgressive-regressive marine cycle. The Windsor grades upwards into red and grey fluviatile sedimentary rocks of the Hopewell Group. The lowest unit in this group is the Maringouin Formation, which marks the transition from marine to continental sedimentation (Gussow, 1953). The overlying red and grey-green sandstones and shale of the Shepody and Enragé Formations were probably deposited in low lying parts of the basin and marginal to the retreating shoreline, whereas the conglomerates of these formations are the proximal facies (van de Poll, 1975). The well-sorted, grey, commonly carbonaceous, sandstones and conglomerates, of the Boss Point Formation, that overlie these rocks probably reflect a fluvio-lacustrine environment (van de Poll, 1972, 1975).

Tectonic activity during this episode is reflected by an angular unconformity between the Shepody and Enragé Formations (Gussow, 1953). In the absence of the Enragé Formation, an unconformity occurs between the Shepody and Boss Point Formations. The marked change in depositional environment that occurred during this episode can be accounted for by a change in climate, and epeirogenic movements that followed block and/or wrench faulting. Evidence for the latter lies in the east to east-northeast trending faults that merge with northeast trending faults and disappear beneath the Pennsylvanian (Boss Point Formation) cover (Fig. 1A). Small right lateral offsets have been observed on the easterly trending faults, but block and/or previous wrench movement may also have occurred. Folding about northeast to east-northeast axes may have been associated with this faulting.

Another angular unconformity separates the coal bearing Pictou Group from the McCoy Head and/or Boss Point Formations (Figs. 1A and 4). The writers believe that this unconformity may be associated with folding and thrusting towards the northwest. Effects of thrusting are clearly seen along the Bay of Fundy coast, and are in part

		AGE	ACADIAN OROGEN: Tectonic Event	ACADIAN OROGEN: Mineral Deposits and Host Rocks	FUNDY CATACLASTIC ZONE AND VICINITY: Tectonic Event	FUNDY CATACLASTIC ZONE AND VICINITY: Mineral Deposits and Host Rocks	SUCCESSOR BASINS: Tectonic Event	SUCCESSOR BASINS: Mineral Deposits and Host Rocks	FORMATION
		PERMIAN							
PENNSYLVANIAN	UPPER	STEPHANIAN						27 Coal grey-green sandstone and siltstone	PICTOU GROUP
PENNSYLVANIAN	UPPER	WESTPHALIAN			NW SE		NW SE	26, 25 Cu,U grey carbonaceous sandstone, shale, and conglomerate	McCOY HEAD FORMATION; BOSS POINT FORMATION
PENNSYLVANIAN	UPPER	NAMURIAN	NE		NE		NE-ENE ENE		ENRAGE FORMATION; SHEPODY FORMATION; MARINGOUIN FORMATION
MISSISSIPPIAN	LOWER	VISEAN						24, 23 Na,K evaporites overlying limestone; 22 Mn veins in limestone; 21, 20 Ba,Sr veins cutting limestone; 19, 18 Cu,Pb,Zn porous and/or fractured zones in limestone and conglomerate	WINDSOR GROUP
MISSISSIPPIAN	LOWER	TOURNAISIAN	NNW SSE N W E	10, 9 Sn,W Mo,Bi fractured subvolcanic stock; 8 Cu,Pb Zn shears cutting granite; 7, 6 Cu,Mo disseminated and along minor fractures in granite; 5 Cu,Mo fracture zones in granite; 4 Sb quartz-carbonate veins cutting slate and greywacke; 3 W,Mo As,Cu greisen veins cutting early and late granitic phase	NNW SSE ENE WSW	12 Cu quartz-carbonate veins cutting Precambrian volcanics; 11 Pb,Ag Zn,Cu fracture zone along granite-sandstone contact	NE NE-ENE ENE WSW	17 Cu conglomerate, sandstone; 16 U conglomerate, sandstone; 15 U albertite vein; 14 Alb bituminous shale and sandstone; 13 Cu fracture zone cutting quartzite	MONCTON FORMATION; ALBERT FORMATION; MEMRAMCOOK FORMATION
		UPPER DEVONIAN	NW SE SW NE	2 Au,As cross folds and quartz veins cutting slate					
		MIDDLE DEVONIAN	NW SE NE NNE	1 Ni,Cu gabbro and norite					
		LOWER DEVONIAN	SW SSW *appears to be confined to Mount Pleasant area						

13 BLACK RIVER copper
12 VERNON copper
11 SCOTT FALLS base metal
10 TRUE HILL tin-base metal
9 RESERVE BROOK base metal
8 MOUNT PLEASANT polymetallic
7 VICTORIA LAKE molybdenum
6 EAGLE LAKE copper
5 EVANDALE copper
4 LAKE GEORGE antimony
3 SQUARE LAKE tungsten
2 ROLLINGDAM gold
1 ST STEPHEN nickel-copper

27 DUNSINANE coal
26 NEW HORTON copper
25 DORCHESTER copper
24 PENOBSQUIS salt-potash
23 SALT SPRINGS salt-potash
22 MARKHAMVILLE manganese
21 DORCHESTER barite-celestite
20 MEMRAMCOOK barite-celestite
19 CEDAR CAMP base metal
18 PEEKABOO CORNER base metal
17 GOSHEN copper
16 WEST MILL SETTLEMENT uranium
15 HAMPTON uranium
14 ALBERT MINES copper

▲ Pyrrhotite, copper-nickel sulfide occurrences
⚠ Tungsten, tin, molybdenum, base metal sulfides in quartz or greisen veins cutting granitic rocks
△ Copper, molybdenum, base metal sulfides disseminated and along minor fractures
▲ Tin, tungsten, molybdenum, bismuth, base metal sulfides in subvolcanic stocks
⊘ Base metal sulfides, gold, antimony, barite-celestite in carbonate or quartz-carbonate veins and locally cross-folds
■ Base metal sulfides in limestone and underlying clastic sedimentary rocks
◪ Base metal sulfides and oxides and/or uranium in sandstone and conglomerate
◓ Coal
○ Miscellaneous industrial minerals

Upwarping
Block faulting
Tension fractures
Kink banding
Cross-folding
Thrusting
Wrench faulting with/without related fold axes and secondary shears
Acadian polyphase deformation

Table I

Mineral deposits related to post-Acadian tectonic evolution, southern New Brunswick.

superimposed on the Fundy Cataclastic Zone (Ruitenberg *et al.*, 1973). Rast and Grant (1973) have associated this thrusting with the development of the post-Acadian penetrative fabric (in the "Fundy Cataclastic Zone"), but our observations indicate that these are related to two distinct events separated by a considerable time interval (Table I) (Ruitenberg *et al.*, 1973).

Post-Acadian Mineral Deposits

Epigenetic, post-Acadian, mineral deposits in southern New Brunswick are associated with Middle-Devonian to Lower Carboniferous intrusions and subvolcanic stocks. Stratiform deposits were formed in Carboniferous fluviatile-lacustrine or lagoonal clastic sediments and carbonate-evaporite sequences. Mineralized veins resulting from partial remobilization of Precambrian and Silurian stratiform volcanogenic deposits (Ruitenberg, 1972; Ruitenberg *et al.*, 1972) are not considered in this report.

Both the epigenetic and stratiform, post-Acadian, mineral deposits were formed during distinct episodes in the tectonic evolution (Table I). In addition to the tectonic setting, favourable climatic conditions were important in the formation of these stratiform deposits (van de Poll, 1975; Kirkham, 1973, 1974). The location of various deposits is shown in Figure 1B.

Epigenetic Deposits. The oldest post-Acadian epigenetic deposits in the area are the St. Stephen nickel-copper deposits. These deposits consist of nickeliferous pyrrhotite, minor pentlandite and chalcopyrite that occur as both masive bodies and disseminated blebs in norite and gabbro. The exact time of emplacement of this intrusive complex is uncertain. Conflicting K-Ar ages have been reported (Wanless *et al.*, 1973). However, the intrusion cuts across the penetrative fabric which is believed to have been formed during the Early to Middle Devonian Acadian orogeny (Ruitenberg, 1967).

Many deposits are associated with the late phase of the granitic complex in southwestern New Brunswick, or fracture zones cutting older rocks. Within the late phase of the main batholith and in the satellite plutons of similar age, chalcopyrite and molybdenite occur as disseminations and fracture fillings, like those at Victoria and Eagle Lakes. Effects of potassic, micaceous and argillic alterations, and silicification are common in the mineralized zones. Similar mineralized granitic rocks have been intersected by deep drill holes under the Lower Carboniferous, Mount Pleasant volcanic complex suggesting the consanguinity between the late granite and the volcanic rocks. East to east-northeast trending greisen veins, containing disseminated wolframite, molybdenite and chalcopyrite, also cut across the late phase of the main batholith, as at Square Lake (Ruitenberg, 1969).

Chalcopyrite and molybdenite occur throughout a broad northwest trending fracture zone that cuts across a granodiorite stock at Evandale. Thin potassium-rich aplitic dykes occur throughout this fracture zone. The host rocks yielded a K-Ar age of 371 ± 20 m.y. (written commun., M. Shafiqullah, 1975). Numerous base metal sulphide ± tin ± molybdenum showings occur along northwest trending shear zones in the satellite plutons, as at True Hill and Reserve Brook. In general, it appears that chalcopyrite is most abundant in the felsic stocks that intrude mafic volcanic rocks (i.e., Evandale and Eagle Lake).

The large tungsten-molybdenum-tin-bismuth-base metal sulphide deposits at Mount Pleasant (Fig. 2) occur in a Lower Carboniferous, intensely altered, rhyolitic subvolcanic complex emplaced in a northwest trending rift zone (Ruitenberg, 1967, 1972). Rhyolite porphyry intrudes and partly overlies intensely brecciated Upper Silurian greywacke and slate. The rhyolite porphyry is intruded by latite porphyry, which is in turn cut by banded rhyolitic pyroclastic rocks. The latter represent remnants of volcanic necks. Emplacement and collapse of this volcanic complex was followed by: 1) weak pervasive silicification, sericitization and chloritization; 2) intense silicification accompanied by kaolinization; and 3) emplacement of metallic oxides and sulphides accompanied by silica, fluorite, topaz, kaolin, tourmaline and chlorite. The tungsten-molybdenum-bismuth ore bodies occur in highly brecciated and silicified, banded pyroclastics (volcanic necks). Tin and base metal sulphides are most abundant in the rhyolite and latite porphyries, along the contacts of the silicified volcanic necks. The main controlling structure is a typical collapse breccia which was formed after extrusion of large amounts of ash flow tuff. Alteration and metallization resulted from fumarolic activity, that occurred during the waning stages of volcanism.

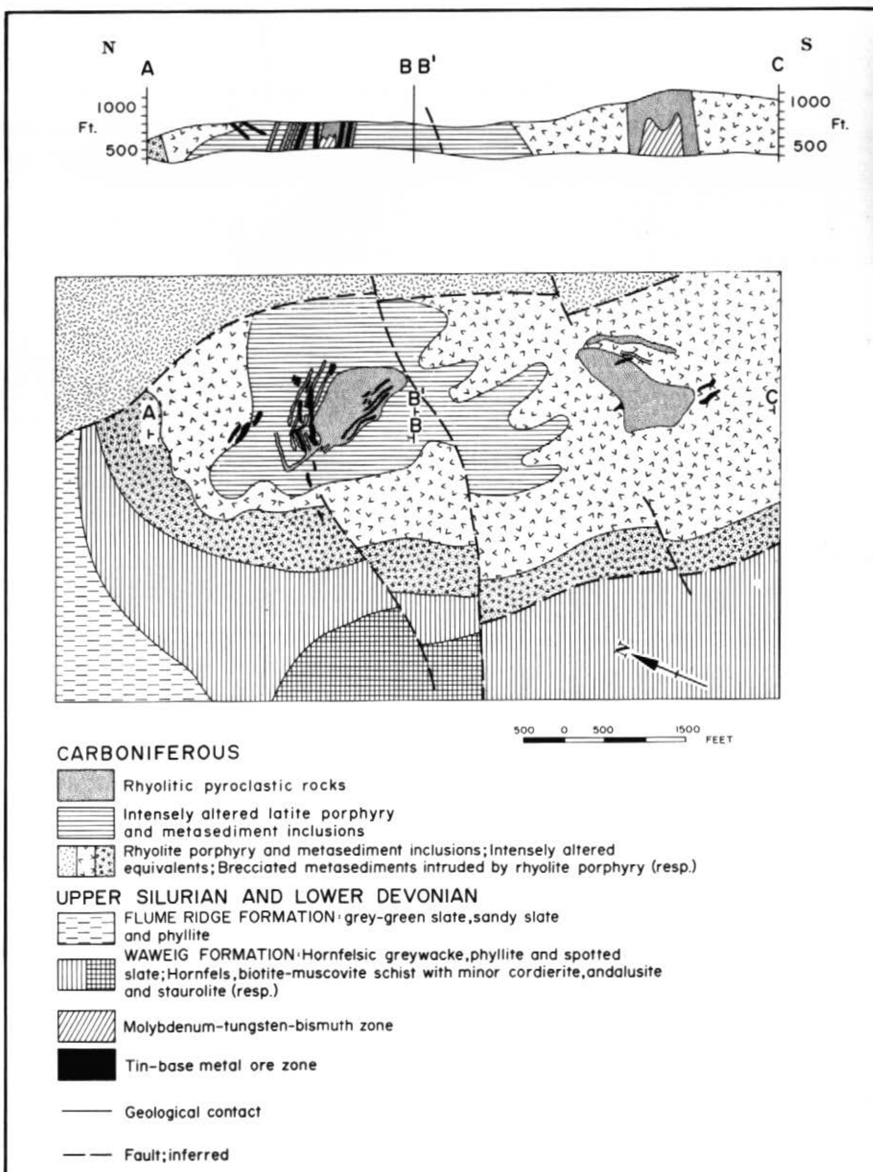

Figure 2

Geology of Mount Pleasant (after Ruitenberg, 1967 and written commun. T.V. Tully, 1973).

The Lake George antimony deposit (Fig. 3) consists of stibnite bearing lenses and fracture fillings in quartz-carbonate veins. The veins occupy east-northeast and north-northwest trending fracture zones that cut across a Silurian greywacke-slate sequence, which has been intruded by feldspar-quartz porphyry and biotite-rich mafic dykes.

A brief examination of the available drill core and underground workings at the Lake George Mine by G. A. Pierce and A. A. Ruitenberg showed that effects of several alteration phases can be distinguished. The earliest consists of a patchy red-brown biotite alteration, followed by a green micaceous and argillic alteration that intensifies towards the ore zone. The core of this altered zone was subsequently silicified. Intense fracturing and/or brecciation of parts of this silicified zone permitted emplacement of the metallic minerals. The main ore shoots occur in the east-northeast trending fracture zone (mainly extension) that dips about 30 to 40 degrees to the north (towards the granite, Fig. 1A) and small amounts of metallic minerals also occur along the northwesterly trending fracture zones. The Lake George deposits and other antimony occurrences in southern New Brunswick possibly formed in Early Carboniferous time because: a) the mineralized structures cut across the typical Acadian (Early-Middle Devonian) penetrative fabric, and b) the altered feldspar-quartz porphyry dykes closely resemble rocks of the second phase of volcanism at Mount Pleasant.

In the Rolling Dam area gold and arsenopyrite occur disseminated through quartz veins that occupy east-northeast trending extensional fractures, or crests of cross-folds in graphitic slate.

Several small epigenetic mineral deposits were emplaced in fracture zones that cut Precambrian to Lower Carboniferous rocks, within and along the margins of the Fundy Cataclastic Zone (Fig. 1A). At Scott Falls, high silver-lead-zinc-copper sulphides are disseminated throughout a fault-fracture zone along the contact of granitic rocks, of possible Ordovician age, and Lower Carboniferous clastic sedimentary rocks (Ruitenberg, 1969). The Black River deposit farther to the east is composed of copper sulphides disseminated through a broad fracture zone in Upper Devonian or Lower Carboniferous quartzite, about 100 metres above the contact with andesitic rocks of the Coldbrook Group (Upper Precambrian) (Ruitenberg, 1970; Ruitenberg *et al.*, 1972). The Vernon copper deposit consists of a series of small, high-grade copper sulphide bearing lenses in brecciated carbonate-quartz veins that cut across Upper Precambrian volcanic rocks (Ruitenberg *et al.*, 1972).

Stratiform Deposits. Post-Acadian stratiform and related deposits include oil, oilbearing shale, coal, limestone, gypsum, salt, potash, barite, celestite, manganese, uranium and base metal suphides (Figs. 1B and 4; Table I). All these deposits were formed within or along the margins of successor basins developed on Precambrian basement and/or on the Acadian orogen. Contrasting lithologies reflect marked fluctuations in tectonic activity, and climate.

The main stratiform and related deposits in southern New Brunswick and their relationship to regional stratigraphy are shown in Figure 4.

Oil and gas have been produced from sandstone and siltstone in the lower part of the Albert Formation, at Stoney Creek, near Hillsborough for about 70 years. The oil field is on the south dipping limb of a monoclinal fold or anticline (van de Poll, 1972). The Albert Formation also contains oil-bearing shale and the solid hydrocarbon, albertite (gilsonite). Greiner (1962) and van de Poll, (1972) suggest that the Albert Formation represents a lacustrine deposit formed under reducing conditions, based on the presence of plant fragments, mud balls and pyrite, and the absence of marine fossils. The local presence of salt and

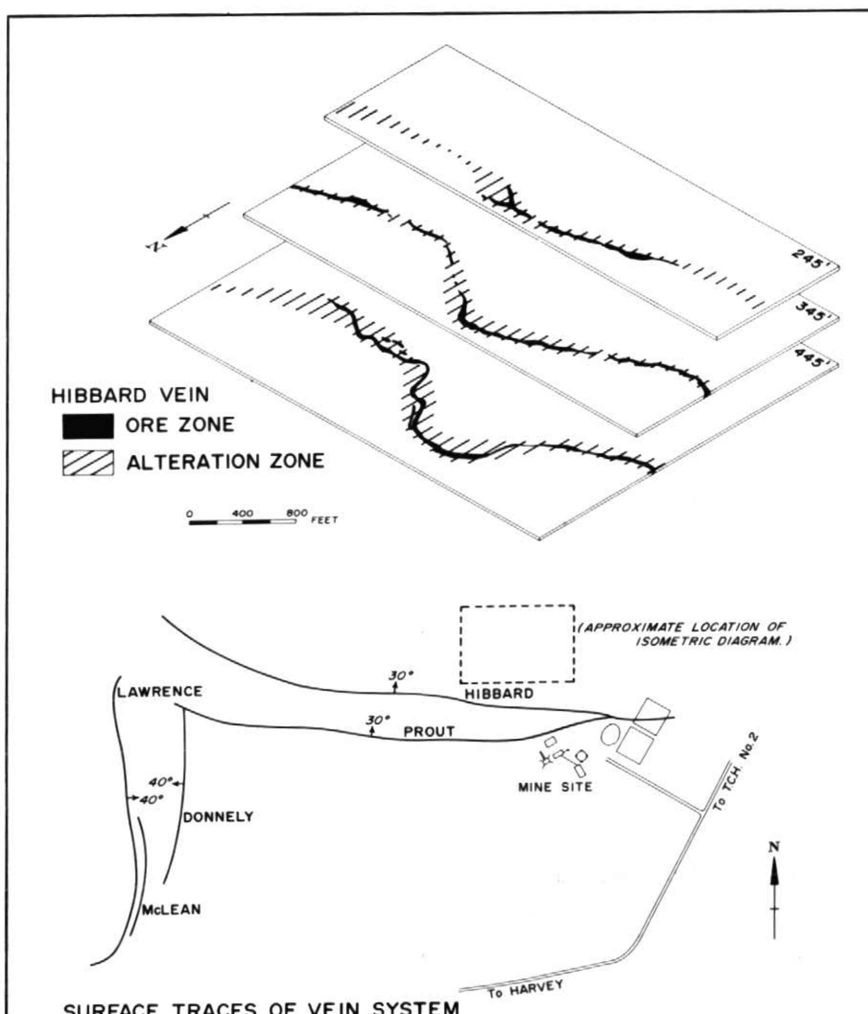

Figure 3
Geology Lake George Antimony Deposit (simplified after unpublished map by B. Bourgoin and T. Atkinson).

limestone beds (Waugh, 1976) however, suggests a lagoonal marine environment, but more detailed investigation is required to establish this. Varying amounts of uranium occur locally in bituminous material of the Albert Formation, northeast of Hampton.

The Windsor carbonates and evaporites are economically of great importance. In New Brunswick the basal member consists of stromatolitic, micritic and recrystallized limestone. Minor limestone and anhydrite intercalated with the underlying Moncton clastics may be equivalent to the basal anhydrite found in the Windsor of Nova Scotia. The limestone is overlain by red shale and evaporites which are capped by anhydrite and/or red shale.

High grade limestone and gypsum are produced from the lower part of the sequence in the Havelock and Hillsborough areas, respectively (Hamilton, 1965; Hamilton and Barnette, 1970). Manganese deposits (pyrolusite and manganite) are interstratified with the carbonate sequence in several localities, including Markhamville. Barite and celestite occur as irregular veins and replacement type deposits associated with the Windsor Group in the Dorchester and Memramcook areas. Bedded and residual deposits are not known in the area (Hamilton, 1968).

Recent discovery, in the upper Windsor, of commercial grade sylvinite associated with thick high quality halite, has activated major exploration programs in the Plumweseep and Salt Springs areas. Reported thicknesses of the potash bearing units in the discovery drill holes varied from about nine to 41 metres, and grades ranged from 25 to 31.6 percent K_2O. Schenk (1967) suggested that these evaporite deposits were formed in an intertidal and/or salt flat environment. If this model is correct it would require slow, regular subsidence during deposition to produce the observed thicknesses.

Galena, sphalerite, chalcopyrite and copper oxides occur in dark grey, stromatolitic and/or micritic limestone, and in the immediately underlying Moncton red beds, at Peekaboo Corner and Cedar Camp. A small, high-grade copper deposit occurs in the Moncton Formation at Goshen. Kirkham (1973, 1974) compared base metal sulphide occurrences at the base of the Windsor in New Brunswick and Nova Scotia, with the Kupferschiefer in Germany, and he infers a Sabka type depositional environment similar to that described by Renfro (1974). It is possible that the metal ions for these occurrences were provided by deep weathering of the Upper Precambrian volcanic rocks and the overlying red beds that contain

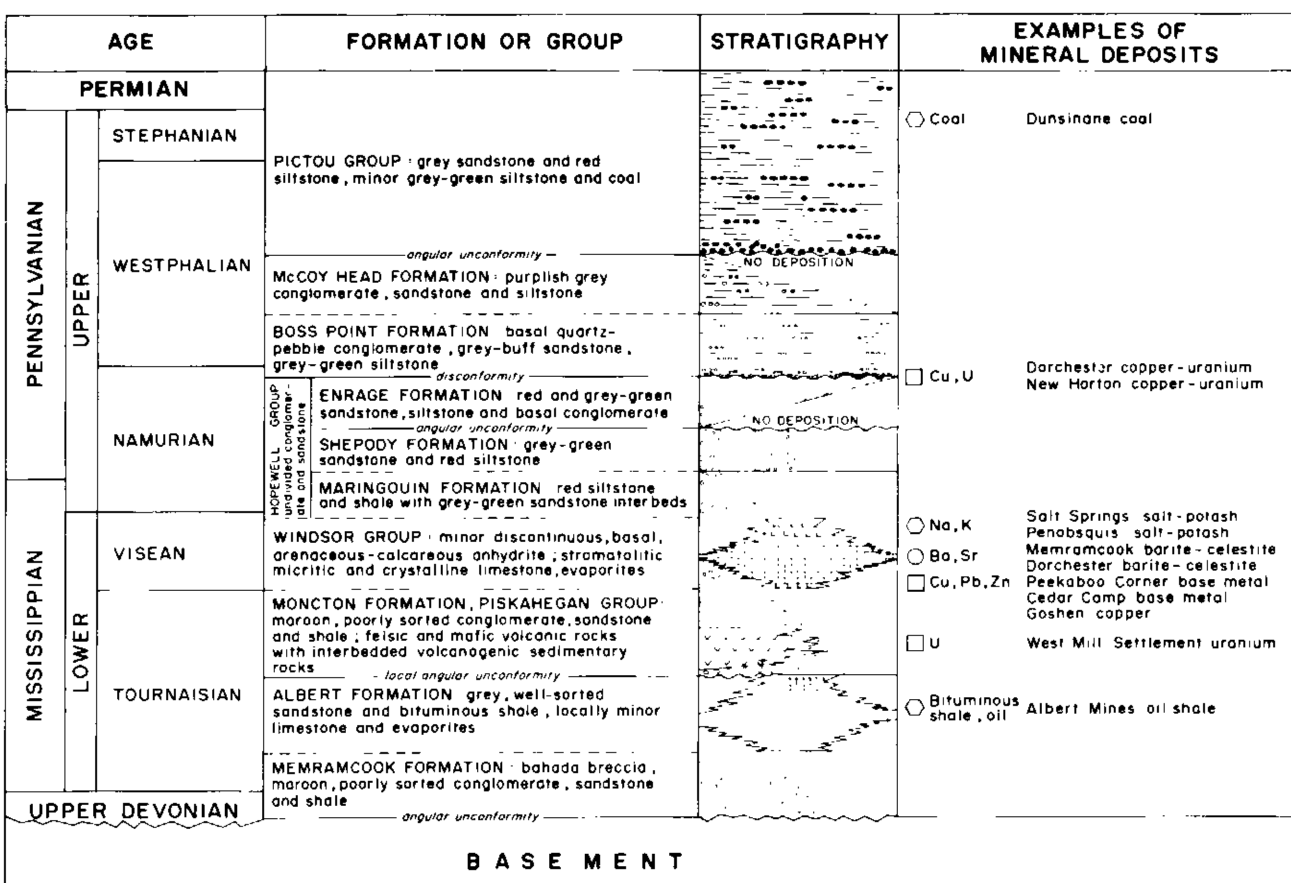

Figure 4
Distribution of mineral deposits in Carboniferous strata in southern New Brunswick.

abundant Precambrian rock fragments.

Uraniferous volcanogenic sandstones and conglomerates composed of altered rhyolite, feldspar, and quartz fragments (Carrow Formation) are intercalated with the basal part of the Piskahegan volcanic sequence (Fig. 5). The uraniferous rocks in the Carrow Formation are intensely chloritized or bleached (altered to fine mica and clay minerals). Pyrite, hematite and locally fluorite are abundant. The uranium ions were probably transported by sulphur-and fluorine-rich water moving through coarse volcanogenic sedimentary rocks (highly permeable) that overlie a thin layer of red siltstone (impermeable) immediately above a massive basalt unit (Ruitenberg *et al.*, 1976). Small amounts of uraniferous minerals also occur in fractures cutting Carboniferous rhyolite, at Harvey.

Several extensive low-grade copper ± uranium deposits, in the Dorchester and New Horton areas, occur in grey carbonaceous sandstone and conglomerate beds (Shepody, Enragé or Boss Point Formations) where they overlie redbeds of the Maringouin Formation (Papenfus, 1931; Flaherty, 1933; Brummer, 1958; van de Poll, 1975). Chalcocite and covellite occur as replacements of carbonized plant fragments in small irregular stringers. Microscopic studies by Flaherty (1933) demonstrated a syngenetic origin for these minerals, although there has locally been remobilization by ground water. Detailed lithofacies studies by van de Poll (1975) indicate that most of these occurrences are just above the facies transition from playa to fluvial strata. Climatic conditions during the formation of these copper deposits favoured deep weathering of the source material - either Precambrian basement or debris derived from it.

The last known stratiform deposit of economic interest, in the map area, is the coal of Dunsinane, just northeast of Sussex. Coal seams varying in thickness from 50 to 75 cm (Lockhart and Sidwell, 1950; Lockhart, 1976) occur in a grey, grey-green and red sandstone-siltstone sequence referred to as the Pictou Group. Barrs *et al.* (1963) dated nearby coal occurrences as Wesphalian D and Stephanian. Dowling (1915) correlated the coal bearing strata at Dunsinane with those of the Grand Lake coal basin to the north, but Barrs *et al.* (1963) state these deposits are Wesphalian C in age. Assay results of the Dunsinane coal are similar to those from Grand Lake (Lockhart, 1976).

Concluding Remarks

The formation of both epigenetic and stratiform mineral deposits in southern New Brunswick can be correlated with distinct tectonic events.

Nickel-copper sulphides in gabbro and norite are the earliest deposits that were formed after the Acadian orogeny (Early to Middle Devonian). These were followed by tungsten, molybdenum, tin and base metal sulphides, which were deposited within and along the contacts of the late phase of a Middle Devonian to Lower Carboniferous granitic complex and associated sub-volcanic stocks. These intrusions were emplaced in a succession of distensional structures that cut across the Acadian orogen and locally the Precambrian basement. It is suggested that antimony deposits in the area were formed as a result of hydrothermal activity associated with

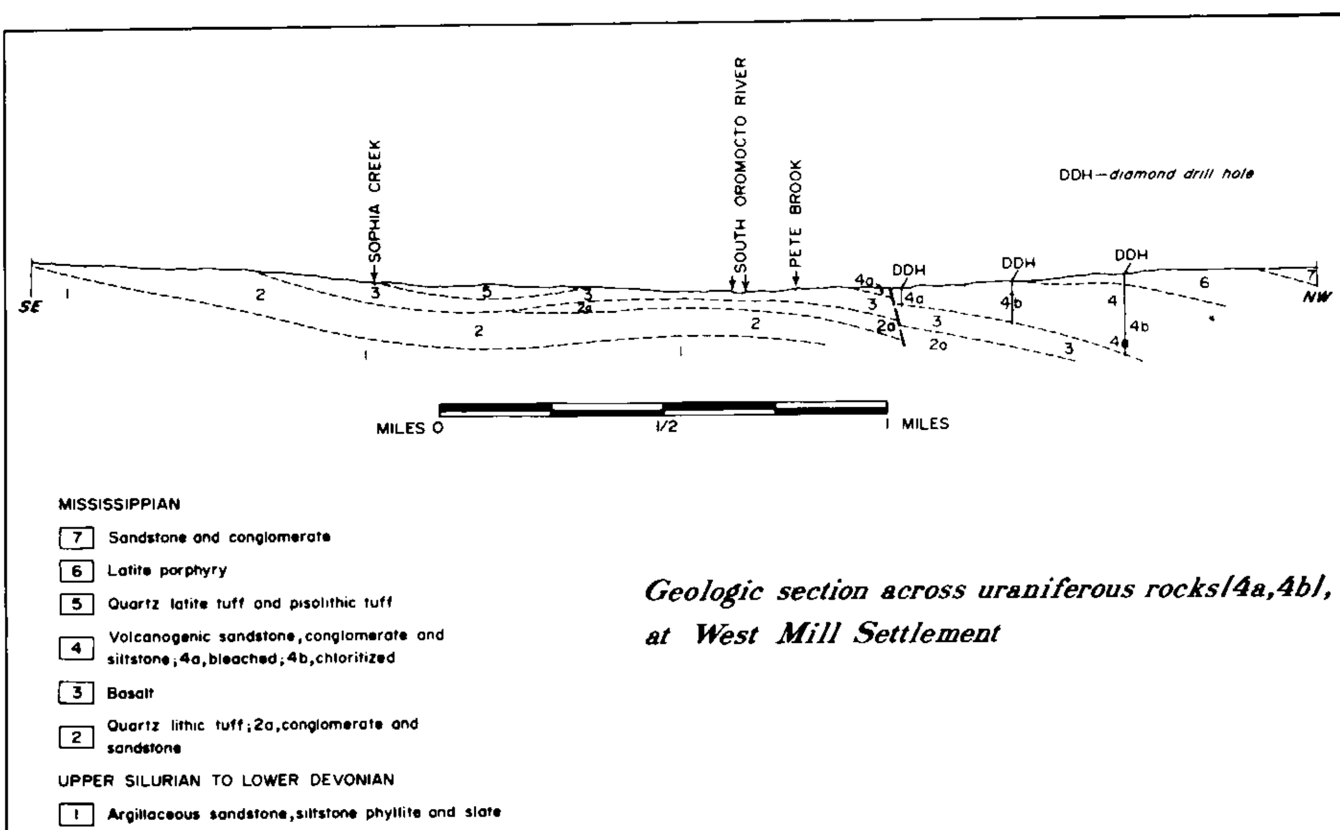

Figure 5

Geologic section across uraniferous rocks (4a, 4b) West Mill Settlement area.

similar Carboniferous (?) intrusives.

The oldest post-Acadian stratiform deposits of economic interest are the oil and oil-shale in the Albert Formation. The local presence of limestone and evaporites in this pyritiferous, carbonaceous sequence suggests a lagoonal marine environment.

The limestone, gypsum and halite-sylvinite deposits in the Windsor Group were probably formed in shallow, slowly subsiding, basins during a major marine transgressive-regressive cycle. The formation of these basins can be accounted for by gentle epeirogenic movements that followed an episode of intense tectonic activity, reflected by the poorly sorted clastics of the Moncton Formation. Base metal sulphide occurrences at the base of the Windsor limestone and in the immediately underlying Moncton redbeds may reflect a sabka-type depositional environment.

The altered uraniferous sandstones and conglomerates interbedded with the Piskahegan volcanic rocks (stratigraphic equivalents of the Moncton Formation) were probably formed as a result of sulphur- and fluorine-rich water moving through coarse (permeable) beds. It is possible that the sulphur- and fluorine-rich water was associated with a nearby volcanic centre. The uraniferous minerals that occur in fractures cutting the Harvey volcanic rocks (similar to the Piskahegan volcanic rocks) were probably formed as a result of hydrothermal activity.

Numerous low-grade copper ± uranium deposits formed in Pennsylvanian carbonaceous clastic sedimentary rocks that overlie redbeds. This change in lithology marks a transition from an arid to a humid climate (van de Poll, 1975). Structural evidence indicates a transition from an episode of active faulting and folding to one of gentle epeirogenic movements. This change in tectonism favoured the formation of extensive fluviatile-lacustrine environments of deposition.

The fauna in the coal deposits of the Pictou Group at Dunsinane and the Minto basin to the north reflect a limnic depositonal environment (Hacquebard, oral commun., 1975). The angular unconformity that separates the Pictou Group from the McCoy Head and/or Boss Point Formation is believed by the writers to be associated with folding and thrusting to the northwest. Thrusting has affected both Carboniferous rocks and Precambrian basement rocks in the Fundy Cataclastic Zone along the Bay of Fundy coast.

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