CHAPTER 2

OBSERVATIONS AND RESULTS OF INVESTIGATIONS

Examination of the majority of the known barite, celestite and fluorite occurrences in Nova Scotia provided information which made observations on the following topics possible:

(a) the distribution of the showings with regard to the three classes of host rocks--igneous, sedimentary and metamorphic; some pertinent chemical statistics of the host rocks; and the modes of occurrence of the mineralization which has taken place in these rocks.

(b) styles of deposits present in Nova Scotia,

(c) where each deposit fits into the style classification scheme,

(d) the spatial distribution of the occurrences with regard to the geology of Nova Scotia, i.e. specific rock groups and/or formations, and to prominent geological features such as unconformities, fault systems, paleogeography, etc., and

(e) other noteworthy features.

These topics are discussed below.

The Distribution of Barite, Celestite and Fluorite in Sedimentary, Igneous, and Metamorphic Rocks in Nova Scotia

Seventy per cent of the occurrences are hosted by sedimentary rocks: conglomerate, sandstone, siltstone, shale, limestone, limestone breccia-conglomerate, dolomite and gypsum. These host rocks are generally Carboniferous in age and primarily Lower Carboniferous. The minerals are found as fissure fillings, solution cavity fillings, pore space fillings and as replacement phenomena.

The chemical statistics pertaining to the abundance of Ba, Sr, F, Cu, Pb and Zn in the various sedimentary rock types hosting the minerals are indicated below in Table 2.

TABLE 2

Barium, strontium, fluorine in sedimentary rocks

Rock Type	Locality	Sample No.	Ba	Sr	F	Cu	Pb	Zn
			p.p.m.					
gypsum	Whitehead (Cheverie)	H01-5000	00	1,400	600	10	40	20
gypsum	Whitehead (Cheverie)	H01-5003	200	200	200	10	40	20
limestone	Anthony's Nose	E03-5005	100	100	400	20	110	40
limestone	Black Rock	BC-74-61	2,000	1,000	800	10	50	30
limestone	Black Rock	E06-5015	100	1,000	700	10	90	20
limestone, minor sphalerite, chalcopyrite	Brierly Brook	BC-74-103	2,100	200	600	8,891	1,400	11,515
limestone	Brierly Brook	E09-5001	4,200	600	500	160	150	150
limestone	Brookdale	H16-5000	300	100	300	15	85	130
limestone	Brookdale	H16-5001	3,100	200	400	20	80	180
limestone	Byers Brook	F11-5004	1,200	14,800	700	740	20	110
limestone	Byers Brook	F11-5005	3,600	800	400	60	110	40
limestone	Cape Blue	F12-5000	300	400	400	20	120	40
limestone	Cheverie	BC-74-7	6,600	800	800	10	90	15
limestone	Cheverie	H01-5004	400	400	300	10	20	20
limestone	Detter Creek (McNabs Cove)	F10-5001	1,900	1,600	1,200	150	100	30
limestone	Finlay Pt. (Mill Brook)	T19-1-1	4,400	300	800	150	180	-
limestone	Finlay Pt. (Mill Brook)	T19-3-1	29,800	1,500	800	90	220	-
limestone	Lakevale	F13-5002	100	200	400	10	190	420
limestone	McIssac Point	F12-5002	400	200	300	20	80	310
limestone	Melford	F14-5001	1,900	500	800	10	170	140
limestone	Middle Stewiacke	E03-5001	500	100	500	50	120	50
limestone	Middle Stewiacke	E03-5002	600	100	400	10	130	20
limestone	Rear Black River	T-20.1-2	600	720	450	30	140	-
limestone	Smithfield	E06-5002	600	900	300	25	480	10
limestone	Springville	BC-74-109	9,900	200	300	1,900	76	160
limestone	Sydney River	K01-5002	100	300	300	60	10	25
limestone	Urbania	E03-5006	200	200	600	10	10	20
limestone	Whale Cove	BC-74-45	900	400	300	30	60	10
limestone	Yankee Line	K02-5004	8,500	800	400	40	1,250	50
limestone conglomerate	Big Marsh	E09-5002	11,700	400	300	20	110	40
limestone conglomerate	Big Marsh	E09-5003	700	300	500	20	170	40
limestone conglomerate	East Mountain	BC-74-57	1,900	200	700	113	122	43
limestone conglomerate	Hilden	E06-5011	3,800	500	600	50	80	45
limestone conglomerate	Kempt Shore	BC-74-48	700	500	500	25	71	50

Table 2. (continued)

Rock Type	Locality	Sample No.	p.p.m. Ba	Sr	F	Cu	Pb	Zn
limestone conglomerate	Wheaton Brook	BC-74-20	1,000	400	300	10	80	20
limestone conglomerate	Wheaton Brook	BC-74-21	300	300	1,000	10	80	10
limestone conglomerate	Wheaton Brook	BC-74-22	200	300	1,000	10	80	10
dolomitic limestone	Glenmore Quarry (M. Musquodoboit)	BE-74-54	300	200	1,400	16	56	21
dolomitic limestone	Hilden	BC-74-60	7,400	800	800	80	50	30
dolomitic limestone	Hilden	E06-5007	8,700	500	500	40	70	20
sandy lime-stone minor malachite	Knoydart Brook	BC-74-104	1,100	200	300	8,550	5,700	1,239
shale	Smithfield	E06-5001	700	00	500	10	40	10
carbonaceous siltstone	Spicer Cove	H07-5015	1,200	100	500	10	30	40
siltstone	Bass River	E05-5002	1,300	00	400	10	30	10
siltstone	Beaver Brook	E06-5014	900	100	300	10	10	20
siltstone	Finlay Pt. (Mill Brook)	T19-2-1	2,600	300	810	50	30	-
siltstone	Mabou Mines	T19-4-1	10,500	300	700	50	120	-
siltstone	Rear Black River	T20.1-3	800	200	400	10	30	-
siltstone	Upper Brookfield	E06-5003	600	600	400	10	20	20
qnartz sandstone	Upper Brookfield	E06-5005	500	700	300	20	10	30
quartz arenite	Bass River	E05-5004	600	00	300	10	20	20
quartz arenite, minor specularite	Bass River	BC-74-137	200	00	300	30	40	20
quartz arenite, minor specularite	Bass River	BC-74-144	200	00	500	2	5	20
quartz arenite	Byers Brook	F11-5006	2,600	100	500	10	30	20
quartz arenite	Smithfield	E06-5000	200	100	300	10	30	10
quartz arenite	Spicer Cove	H07-5013	400	100	300	130	20	70
feldspathic arenite	Salmon River Road	F15-5004	1,800	300	700	10	40	100
feldspathic arenite	Spicer Cove	H07-5009	19,100	200	300	5	30	80
feldspathic arenite	Spicer Cove	H07-5012	1,800	100	700	15	50	110
feldspathic arenite	Spicer Cove	H07-5014	1,000	00	300	10	90	320
feldspathic arenite	Spicer Cove	H07-5016	2,300	100	400	20	50	25
arkosic sandstone	Black Brook	H09-5006	900	100	600	20	35	135

Table 2. (continued)

Rock Type	Locality	Sample No.	p.p.m. Ba	Sr	F	Cu	Pb	Zn
arkosic sandstone	Cape Blue	F12-5001	2,700	100	300	20	20	60
arkosic sandstone	Lakevale	F13-5000	600	100	300	10	50	50
arkosic sandstone	Lakevale	F13-5001	2,100	100	400	20	50	110
arkosic sandstone	Middle Stewiacke	E03-5000	1,700	200	300	30	50	10
arkosic sandstone	Presqu'ile	K10-5000	1,200	200	600	10	20	40
micaceous quartz sandstone	Upper Brookfield	E06-5004	800	800	400	10	10	10
lithic sandstone	Frenchvale Bk.	K01-5001	500	300	500	35	25	35
ferruginous sandstone	Cheverie	BC-74-47	9,500	400	600	10	33	21
ferruginous sandstone	Cheverie Point	H01-5002	1,200	800	400	20	40	20
ferruginous sandstone	Sydney River	K01-5000	3,100	200	400	10	50	40
ferruginous quartz sandstone	McIssac Point	F12-5003	4,200	200	300	30	30	120
limonitic sandstone	Goshen	H01-5007	1,300	300	300	20	20	10
limonitic sandstone	Goshen	H01-5008	5,100	400	300	20	20	20
conglomerate	Arisaig Pt.	E16-5001	800	00	400	10	25	25
conglomerate	Balmoral Mills	E11-5002	400	100	300	20	30	80
conglomerate	Byers Brook	F11-5002	18,800	400	400	20	20	30
conglomerate	Brierly Brook	E09-5000	1,200	200	400	20	30	100
conglomerate	East Earltown	E11-5001	300	100	300	10	40	90
conglomerate	Melford	F14-5000	7,000	300	300	10	40	50
conglomerate	Nabiscump Brook	E11-5003	300	100	300	10	40	70
conglomerate	North Earltown	E11-5000	900	100	500	30	50	70
conglomerate	North Greenville	E12-5000	4,300	100	300	170	25	40
conglomerate	North Greenville	E12-5005	4,500	100	400	20	25	55
conglomerate	North Greenville	E12-5006	2,600	100	400	20	25	80
conglomerate	South Brook	H09-5002	1,200	300	300	20	50	55
conglomerate	Spicer Cove	H07-5005	7,100	500	1,700	10	40	450
conglomerate	Spicer Cove	H07-5007	2,000	100	500	15	40	75
conglomerate	Yankee Line	K02-5001	3,800	200	300	60	30	50

The localities where the minerals are hosted by sedimentary rocks are:

*(2) Big Marsh
(3) Brierly Brook
(4) Cape Blue
(5) Lakevale
(6) McArras Brook
(7) McIssac Point
(8) Benacadie Point
(9) Derby Point
(10) Frenchvale Brook
(11) Salmon River Road
(13) Sydney River
(139) Loch Lomond
(14) Bass River
(17) Hilden Prospect
(20) Middle Stewiacke
(21) Smithfield
(22) Southvale
(23) Upper Brookfield Prospect
(24) Urbania
(25) Beckwith
(26) Brookdale
(27) Malagash North Shore
(28) North Greenville
(30) South Brook
(31) Spicer Cove
(32) Byers Brook
(35) Cheverie
(36) Feuchtwanger Property
(37) Goshen
(38) Johnson Cove
(40) Lower Burlington
(42) Walton (Shaw & Churchill Mine)
(43) Wheaton Brook
(44) White Head
(138) Summerville Wharf
\- Walton Mine (Dresser Minerals)
(45) Finlay Point (Mill Brook)
(46) Lake Ainslie
(47) Mabou Mines
(48) Melford
(49) Presqu'ile
(50) Rear Judique South
(52) East River Point
(58) Hodson
(60) Welsford
(61) Detter Creek (McNabs Cove)
(62) Pine Brook
(63) Rear Black River
(64) Yankee Line

Seventeen per cent of the occurrences are hosted by igneous rocks: rhyolite, welded rhyolitic tuff, aplite, granite, granodiorite, quartz monzonite, pegmatite and greisen. The intrusive host rocks are Devonian in age and the extrusive host rocks are Lower Carboniferous and Upper Carboniferous in age. The mineralization which occurred in these rocks is of the fissure filling type.

The chemical statistics pertaining to the abundance of Ba, Sr, F, Cu, Pb and Zn in the igneous host rocks are listed below in Table 3.

The localities where barite and fluorite are found hosted by igneous rocks are:

* The number in parenthesis refers to the location number in Figure 200.

TABLE 3

Barium, strontium, fluorine in igneous rocks

Rock Type	Locality	Sample No.	Ba	Sr	F	Cu	Pb	Zn
			p.p.m.					
welded rhyolite tuff	Arisaig Pt.	E16-5000	3,200	100	500	10	40	50
rhyolite	Spicer Cove	H07-5003	2,800	100	1,000	20	20	30
aplite	Leminster	A16-5002	100	00	2,000	140	30	30
granite	Jollota Prospect	F04-5000	100	100	400	30	30	30
granite	Leminster	A16-5000	200	00	400	50	20	30
granite	Shenacadie	B.11.1-1	800	300	200	50	30	-
granite	Shenacadie	B.11.4-1	450	3,000	550	50	30	-
granite	Shenacadie	B.11.2-2	900	300	200	30	30	-
granite	Shenacadie	B.11.3-2	1,200	200	200	50	30	-
quartz monzonite	Lower Canoe Lake	A16-5003	2,500	100	700	60	20	60
pegmatite	Shenacadie	K02-5006	1,900	00	300	10	10	10

(1) Arisaig Point
(12) Shenacadie
(31) Spicer Cove
(34) Upper Tantallon
(39) Leminster
(41) Vaughan-Leminster Road
(46) Lake Ainslie
 (A) Trout River Area
 (B) Twin Rock Valley Area
 (C) Scotsville Inlier Area
 (E) Gillis Brook
(53) Forties Settlement (Reeves Tin Prospect)
(54) Lower Canoe Lake
(55) New Russel (Walker Prospect)

Thirteen per cent of the occurrences are hosted by rocks of sedimentary origin. The five showings situated in the Cobequid Highlands occur in mudstones, siltstones, and sandstones that are only weakly metamorphosed in some cases, particularly those of the Harrington-East River Sequence. Consequently, some of these showings may actually be included with the group hosted by sedimentary rocks. The metamorphic host rocks range in age from Precambrian to Silurian. The barite, celestite and fluorite mineralization examined in these rocks are of the fissure filling type.

The chemical statistics pertaining to the abundance of Ba, Sr, F, Cu, Pb and Zn in the metamorphic host rocks are outlined below in Table 4.

TABLE 4

Barium, strontium, fluorine in metamorphic rocks

Rock Type	Locality	Sample No.	Ba	Sr	F	Cu	Pb	Zn
siltstone	Bass River of Five Islands	H08-5012	1,300	100	600	10	60	10
siltstone	Bass River of Five Islands	H08-5013	12,800	100	400	20	30	90
feldspathic arenite	East River of Five Islands	H08-5007	500	00	400	30	30	15
siltstone	East River of Five Islands	H08-5008	1,400	100	300	10	40	30
siltstone	East River of Five Islands	H08-5010	800	00	500	10	100	20
slate, shale	Lake Fletcher	D13-5000	1,300	100	300	20	40	90
slate, shale	Lake Fletcher	D13-5002	1,200	100	600	10	70	100
feldspathic arenite	Lynn Road	H08-5001	3,300	400	300	20	20	10
argillite	Nicholsville	A15-5000	3,400	100	500	100	100	50
siltstone	Parrsboro	H08-5003	1,200	200	300	10	40	50
quartz arenite	Parrsboro	H08-5005	1,200	00	400	10	60	20
phyllite	Corney Brook	K10-5001	3,300	100	300	20	25	60

(Values in p.p.m.)

The localities where barite and fluorite are found hosted by metamorphic rocks are:

- (15) Bass River of Five Islands
- (16) East River of Five Islands
- (18) Londonderry
- (19) Lynn Road
- (29) Parrsboro
- (33) Lake Fletcher
- (49) Corney Brook
- (51) Nicholsville
- (56) Bridgeville
- (57) Glencoe Brook

Styles of Deposits Present in Nova Scotia

Six styles of deposits are evident in Nova Scotia. Idealized sketches portraying each of the styles are found in Figure 4. Each style is categorized according to geological characteristics, some of which make it distinct from the others. These characteristics are:

(a) physical form of the deposit,

(b) important features controlling the mineralization,

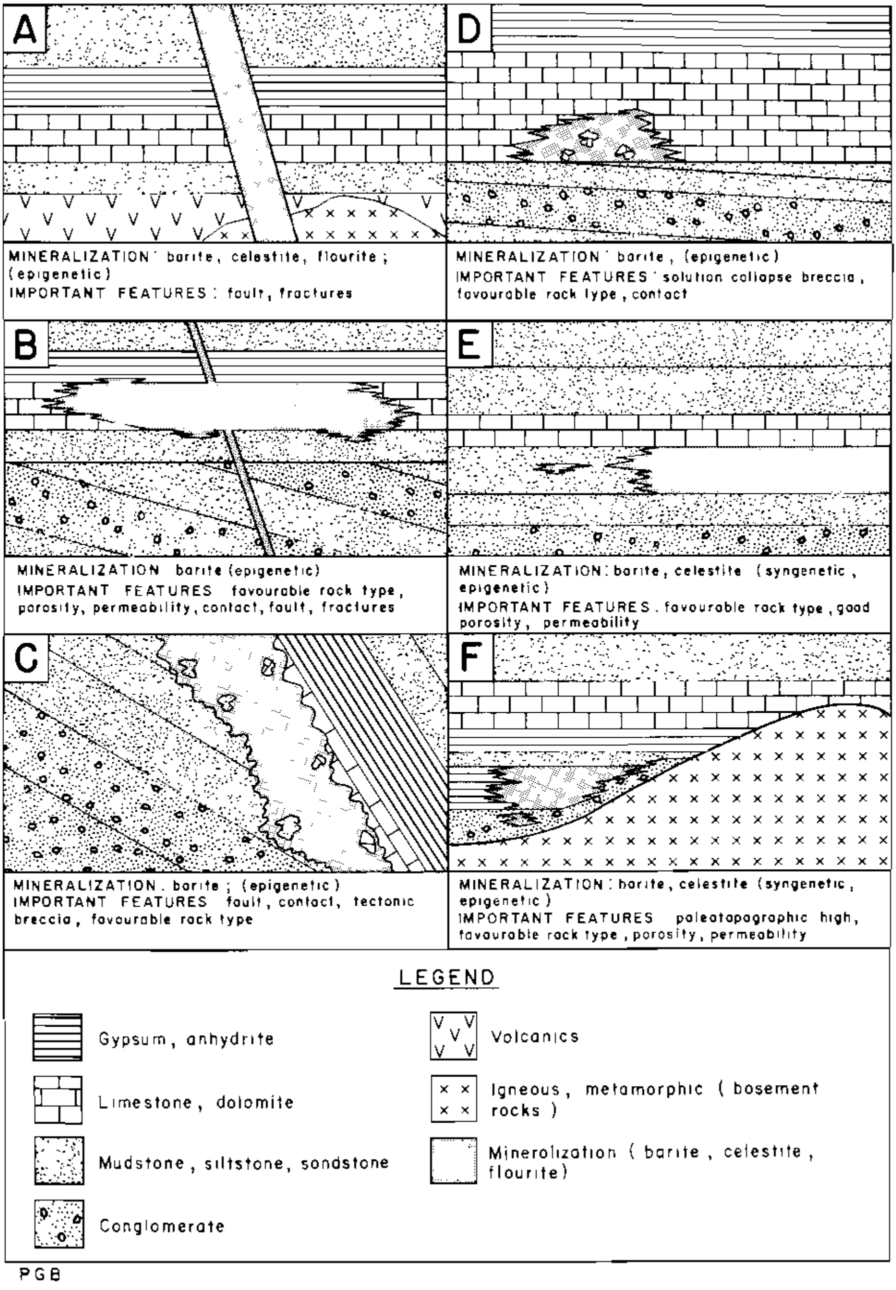


Figure 4 - Idealized sketches portraying the six styles of barite, celestite, fluorite deposits in Nova Scotia.

(c) mineralogy of the deposits (i.e. barite, celestite, or fluorite),

(d) genesis (i.e. syngenetic or epigenetic).

Style A

Deposits characterized by this style are entirely structurally controlled, with little or no replacement of the wallrock taking place. Faults and fracture systems are the structures which typically host this style of deposit. The host rock can be igneous, sedimentary or metamorphic. The general lack of alteration seen in the host rocks adjacent to the mineralized zone suggests that the host rocks were essentially chemically inert to the mineralizing solutions and/or the mineralizing solutions were of the epithermal type. Exceptions to this are the fluorite veins associated with the Devonian granite, pegmatite, and greisen, where significant alteration halos (e.g. hematization), have been observed and the mineralization is probably of the hypothermal type.

The deposits in this style are epigenetic in origin. The type examples are (46) Lake Ainslie (barite-fluorite) and (25) Beckwith (celestite).

Style B

This style of deposit is stratigraphically controlled, with the bulk of the mineralization having taken place within a specific stratigraphic horizon; however, structure plays an important role in the localization of the ore minerals. Replacement of the host rock can range from minor to very extensive. Because the minerals are for the most part strata-bound, this style of deposit generally exhibits a tabular form.

Structural features which are found to accompany this style of deposit include: (a) nearby unconformity, and (b) faults and/or fractures. The significance of the unconformity is not apparent, although it has been suggested in the past that it plays an important role in the migration of ore solutions. The presence of faults and/or fractures (often mineralized) within and at the periphery of the deposit were undoubtedly instrumental in its formation. A rock unit that has undergone fracturing resulting in an enhanced permeability will be made more accessible to migrating ore-bearing solutions and hence facilitate the replacement process. This feature is believed to be significant to this style of deposit.

Stratigraphic features which appear to be of importance (although all need not be present together) to a potential host rock of this style of mineralization are: (a) favourable rock type, (b) porosity, (c) permeability, and (d) competent rock. Whether a rock unit's mineralogy is favorable to a replacement process depends on a great number of variables (i.e. temperature, pressure, composition of the ore-bearing solution, Eh, pH, etc.), consequently deposits are found hosted by both carbonate and terrigenous clastic sedimentary rocks. In general however, carbonates and calcite cemented terriginous clastic sedimentary rocks appear to be more amenable to replacement than siliclastic rocks.

Good primary porosity and intergranular permeability are positive factors for any potential host rock, as they greatly facilitate the replacement process by maximizing exposure of the host rock components to the ore-bearing solutions. In highly porous quartz sandstones, the minerals may be present as a cement evenly distributed throughout the rock, with only negligible replacement of the clasts having occurred.

In the sedimentary environment, competent rocks such as carbonates and most clastic sedimentary rocks will undergo fracturing and maintain these fractures more readily than incompetent rocks such as gypsum. Since fractures play a role in this style of deposit, carbonates and clastic sedimentary rocks are favoured over evaporites.

The wall rocks in this style of deposit examined to date do not exhibit any alteration other than replacement by barite. As in Style A, this suggests that the ore bearing solutions may be of the epithermal type.

The minerals in Style B are considered to be epigenetic in origin. The type examples are (138) Summerville Wharf (barite) and (14) Bass River (barite).

Style C

The deposits characterized by this style are primarily structurally controlled with the host rock type being only of minor importance. The primary structural feature is a fold-fault intersection at an unconformity, which has resulted in the formation of abundant open spaces and tectonic breccia. The filling of the cavities and replacement of the breccia by the ore minerals results in a deposit that can be quite irregular in shape. Variations of the "pipe" shape occur when high angle faults intersect steeply dipping limbs of a fold.

The structural elements outlined above are essential features of this style of deposit, as they are all directly responsible for creating a site characterized by differential pressure. The constituents of ore bearing solutions moving through such a site would be precipitated and thereby establish physico-chemical equilibrium.

Lithologic boundaries are randomly crossed by this type of deposit indicating that host rock type is not a major factor controlling the mineralizing process. Worthy of note, however, is that no occurrences of this style are hosted by igneous rocks and that a carbonate environment is generally favoured over a clastic sedimentary environment.

No alteration of the wall rocks other than replacement by the ore minerals was noted in deposits of this style. Exceptions to this are the Walton barite mine and the Hilden Prospect, where silicification of the limestone host has occurred. As with Styles A and B this suggests that the ore-bearing solutions may be of the epithermal type.

The mineralization characteristic of this style is epigenetic. The type examples are Walton Mine (barite) and (23) Upper Brookfield (barite).

Style D

These deposits are both stratigraphically and structurally controlled. They are stratigraphically controlled in that the minerals are restricted to a specific stratigraphic horizon, and structurally controlled in that the minerals filling cavities and replacing solution breccias. Deposits of this type are variable in shape; however, the lower contact (stratigraphically) is generally more uniform than the upper. The size of the deposit will be determined by the extent of the brecciation and the continuation of the favourable horizon.

Features worth noting concerning this style of deposit are that the known deposits are hosted by carbonates and they occur at or near a contact separating two major rock groups, e.g. Horton-Windsor contact. The contact may be either conformable or unconformable. It is possible that this contact may be of significance with regard to migration of the ore-bearing solutions. Like Styles A, B, and C the creation of open spaces was probably accompanied by physico-chemical disequilibrium. The equilibrium in the system was restored by migration and deposition of the ore minerals at the site of carbonate dissolution.

No wallrock alteration other than replacement by the ore minerals was observed to occur with this sort of deposit. This lack of alteration suggests that the ore bearing solutions may be of the epithermal type.

This style of deposit is considered to be epigenetic in origin. The type examples of deposits characterized by this style are (22) Southvale (barite) and (32) Byer's Brook (celestite and barite).

Style E

This style of deposit is entirely stratigraphically controlled. The strata-bound nature of the mineralized rocks results in a deposit with a relatively uniform, tabular shape. This style of deposit will form when (a) the mineralization is a result of synsedimentary deposition, and (b) the replacement of the host rock by ore minerals is controlled by favourable rock type, good primary porosity and permeability. The deposition of synsedimentary minerals is a function of basin conditions at the time of sedimentation. The determination of these conditions requires a more detailed study than is intended for this report.

The features favouring replacement of the host rock by ore minerals in this style of deposit are best fulfilled by sedimentary rocks. These rocks may either be clastic or carbonate in nature, and should possess a fairly high degree of porosity and intergranular permeability to allow easy migration of the ore-bearing solutions. Sharp contacts of the replaced bed with the beds forming the footwall and hangingwall may indicate the absence of one or more of the favourable features in those beds bounding the deposit. A non-porous, impervious hangingwall could be an additional factor in controlling the localization of ore minerals, by restricting migration of the ore-bearing solutions to a specific sedimentary horizon.

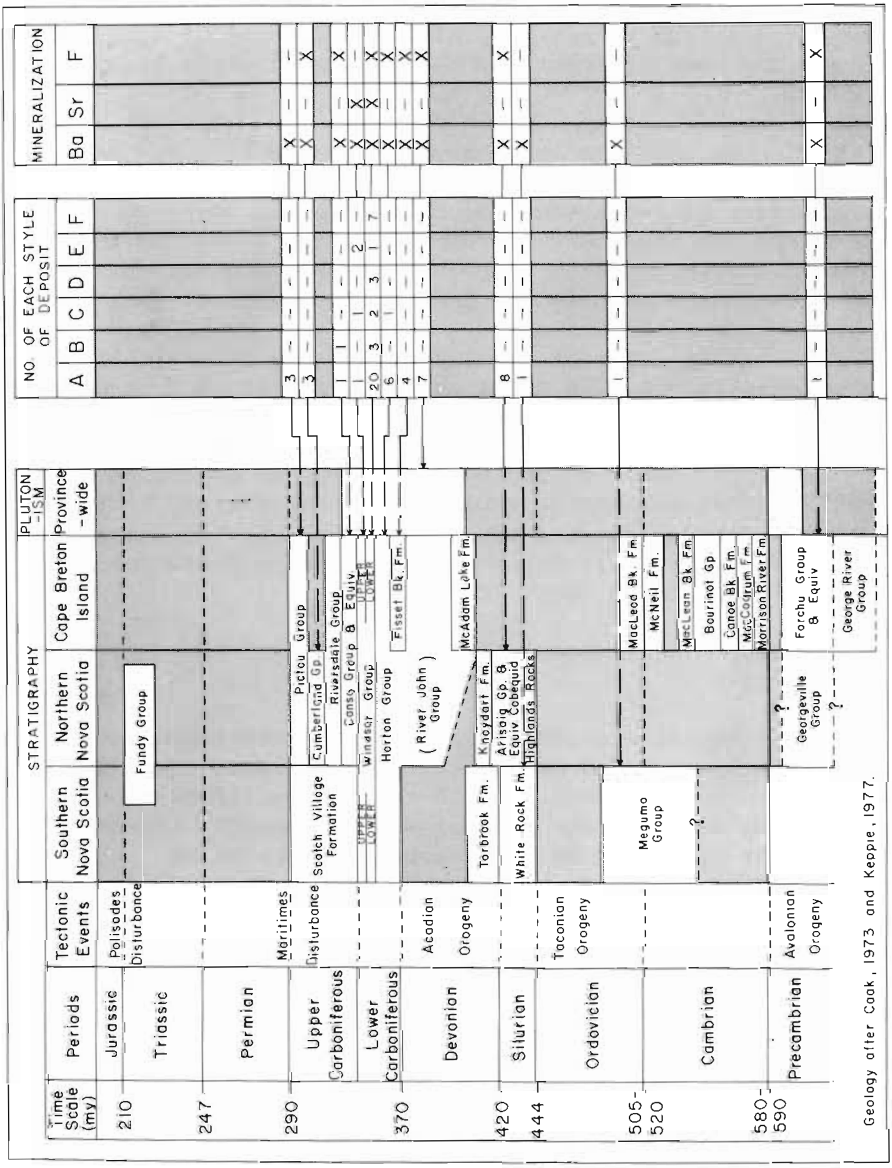
As with the other styles of deposits, no alteration of the wallrocks was observed, suggesting that in the case of replacement deposits the ore bearing solutions may have been of the epithermal type. In the case of a synsedimentary deposit, the low temperature of the solutions is implied by the nature of its origin.

This style of mineralization may be syngenetic or epigenetic(?). The syngenetic type includes minerals deposited through synsedimentary processes and diagenetic replacement. Insufficient study has been undertaken on the deposits characterized by this style to determine whether those exhibiting replacement features are of the diagenetic or epigenetic type. Type examples of deposits characterized by this style are (6) McArras Brook (barite) and (10) Frenchvale Brook (celestite).

Style F

Deposits characterized by this style are both stratigraphically and structurally controlled. They are stratigraphically controlled in that the wallrocks consist of bedding layers above and below the deposit. Structural control is indicated by the nearby presence of an unconformity in the form of sedimentary beds occurring as an onlap on older basement rocks which form a paleotopographic high. This style of deposit will be essentially tabular in shape because it is strata-bound.

Rock types favouring this style of mineralization are calcite cemented terriginous clastic sedimentary rocks and carbonate rocks. Good porosity and intergranular permeability appear to have been significant as suggested by: (a) the sympathetic relationship between the deposits and the near shore facies of the depositional basin, and (b) the termination of some of the deposits in gypsum in a


Time Scale (my)
Periods
Tectonic Events
STRATIGRAPHY
Southern Nova Scotia
Northern Nova Scotia
Cape Breton Island
PLUTON -ISM
Province -wide
NO. OF EACH STYLE OF DEPOSIT
A
B
C
D
E
F
MINERALIZATION
Ba
Sr
F
210
247
290
370
420
444
505-
520
580-
590
Jurassic
Triassic
Permian
Upper Carboniferous
Lower Carboniferous
Devonian
Silurian
Ordovician
Cambrian
Precambrian
Palisades Disturbance
Maritimes Disturbance
Acadian Orogeny
Taconian Orogeny
Avalonian Orogeny
Fundy Group
Scotch Village Formation
UPPER
LOWER
Torbrook Fm.
White Rock Fm.
Meguma Group
Pictou Group
Cumberland Gp
Riversdale Group
Canso Group & Equiv.
Windsor Group
Horton Group
Fisset Bk. Fm.
(River John) Group
McAdam Lake Fm.
Knoydart Fm.
Arisaig Gp. & Equiv Cobequid
Highlands Rocks
MacLeod Bk. Fm.
McNeil Fm.
MacLean Bk. Fm.
Bourinot Gp.
Canoe Bk. Fm.
MacCodrum Fm.
Morrison River Fm.
Georgeville Group
Forchu Group & Equiv.
George River Group
Geology after Cook, 1973 and Keppie, 1977.
P.G.R.

down-dip direction. The presence of gypsum is a noteworthy feature in the occurrence of this style of deposit, particularly celestite.

No wallrock alteration was observed to be associated with this style of deposit, indicating that the mineralizing solutions may have been of the epithermal type. Various individuals (Choo, 1972; Crowell, 1971; Forgeron, 1977; Hudgins, 1968) have put forth evidence supporting both syngenetic and epigenetic origins. Diagnostic evidence eliminating one or the other has yet to be produced.

Type examples of deposits characterized by this style are (11) Salmon River Road (barite), and (139) Loch Lomond (celestite).

The Style Classification of the Barite, Celestite, Fluorite Showings in Nova Scotia

Figure 200 indicates where each occurrence fits in the classsification scheme. The classification of some of the showings may change as additional information is obtained, either through more detailed mapping or diamond drilling. It should also be noted that although celestite and/or fluorite are absent from some of the classifications, it does not preclude them from occurring in these styles. It merely indicates that all the classifications are not represented by the fluorite-celestite occurrences investigated. Listed occurrences that were not categorized are those that were not examined in the field.

Figure 5 - The distribution and number of the various styles of barite, celestite, fluorite deposits observed in Nova Scotia with regard to the International Time Scale and Nova Scotia geology. The distribution of barium, strontium, and fluorite as represented by barite, celestite and fluorite mineralization with regard to Nova Scotia geology and the International Time Scale is also shown.

The Spatial Distribution of the Barite, Celestite, Fluorite with Regard to the Geology of Nova Scotia

The spatial distribution of the barite, celestite, fluorite occurrences with regard to the geology of Nova Scotia is summarized in Figures 5 and 200. The most noteworthy features are listed below.

(1) The majority of barite occurrences have been found in Lower Carboniferous rocks, and of these most occur in the Lower Windsor Group.

(2) With the exception of two barite occurrences found in Upper Carboniferous rocks, all barite and celestite occurrences in Styles B to F inclusive have been found in Lower Carboniferous strata with carbonates being the most common host.

(3) All celestite deposits have been found in rocks of Lower Carboniferous age.

(4) A significant number of barite and barite-fluorite occurrences are situated in close proximity to the Glooscap Fault System, a large proportion of which show a close spatial relationship between north-south and northwest-southeast trending offset faults*.

(5) The majority of the fluorite showings are hosted by granitic rocks of Mid-Devonian Age.

(6) Style A (fissure filling) occurrences show the greatest stratigraphic range, occurring in rocks from Precambrian to Upper Carboniferous in age.

(7) A large number of the showings are situated at or near the Horton Group-Windsor Group contact.

(8) In the Minas sub-basin the number of barite occurrences increase sympathetically with the increase in

* The association of mineralization with north-south and northwest-southeast trending faults was recognized by the author at (14) Bass River and (16) East River of Five Islands; however, the remainder, (19) Lynn Road, (15) Bass River of Five Islands and (29) Parrsboro were recognized and brought to the writer's attention by Donohoe and Wallace (personal communication, 1978).

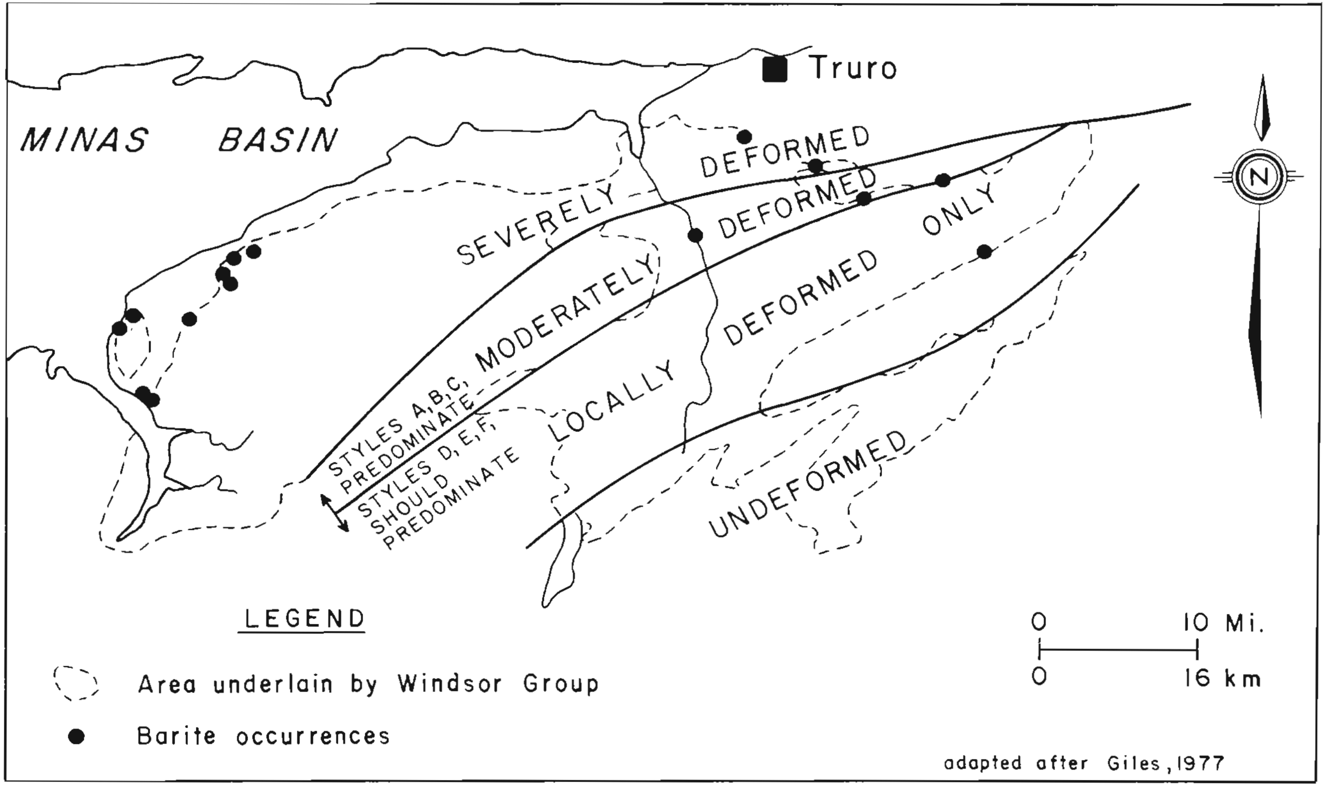


Figure 6 - The distribution of barite occurrences in the Windsor Group in the Minas sub-basin area with respect to structural complexity. The line separating the "moderately deformed" and "locally deformed only" regions is suggested as a boundary between areas where styles A, B, and C deposits predominate and styles D, E, and F deposits should predominate.

intensity of deformation of the Windsor Group (Fig. 6). The good correlation between severely and moderately deformed regions, and structurally controlled barite, fluorite deposits of the A, B, and C styles is noteworthy.

(9) the youngest rocks hosting barite, celestite and fluorite minerals are those of Carboniferous age.

(10) No evidence of celestite mineralization was observed south of the Glooscap Fault System.

(11) Paleogeography appears to play an important role in Style F barite and celestite deposits.

(12) A significant portion of the occurrences hosted by Upper Carboniferous rocks are situated in the south limb of the northeasterly trending Athol and Tatamagouche Synclines. These occurrences are: (28) North Greenville, (30) South Brook, (31) Spicer Cove, (58) Hodson, and (60) Welsford.

Other Pertinent Observations and Results

(1) Barium is present wherever manganese oxides occur. The barium may be included in a manganese oxide mineral such as psilomelane, and/or be present as barite.

(2) The presence of hydrocarbons in the form of carbonaceous material and/or bitumen in either the host rock or the mineral deposit itself is a noteworthy feature at a number of occurrences. These include (27) Malagash North Shore, (110) Cribbon's Point and (134) Melmerby Beach in the Upper Carboniferous rocks; and (23) Upper Brookfield, (35) Cheverie, (36) Feuchtwanger Property and (136) Jubilee Prospect in the Lower Carboniferous rocks.

(3) While barite and fluorite is a fairly common association, celestite and fluorite is not.

(4) Barite, celestite, and fluorite have not been found to occur together.

(5) Chemical analysis indicates that barium and strontium are almost always associated with each other. However, one will generally predominate over the other, with the least dominant one never exceeding a few per cent of the total. (The Frenchvale Brook occurrence is an

exception.) Since barium and strontium are diadochic, where one forms the minor constituent, it need not be present as a separate mineral species, but as an integral part of the mineral forming the major portion of the deposit.

(6) Barite and fluorite have been found together only as fracture fillings.

(7) Post-mineralization movement as evidenced by brecciation, shearing and off-setting of the mineralized zone was observed at a number of occurrences. These include: (1) Arisaig Point, (139) Loch Lomond, (17) Hilden, (19) Lynn Road, (20) Middle Stewiacke, (21) Smithfield, (23) Upper Brookfield, (25) Beckwith, (34) Upper Tantallon, (36) Feuchtwanger Property, (37) Goshen Prospect, Walton Mine, (49) Corney Brook, and (56) Bridgeville.

(8) Microscopic textures which are encountered in various barite occurrences are briefly described and pictorially illustrated. Those of particular interest include: Figure 27, (11) Salmon River Road; Figure 39, (14) Bass River; Figure 67, (22) Southvale; Figure 116, (36) Feuchtwanger Property; Figure 143, (47) Mabou Mines; and Figure 189, (64) Yankee Line.

CONCLUSIONS AND RECOMMENDATIONS

Age of Mineralization of Barite, Celestite and Fluorite in Nova Scotia

The results of the investigations do not provide conclusive evidence pertaining to age(s) of mineralization; however, there is sufficient data to allow speculations and/or suggestions as to possibilities that can be considered. Excluded from the following suggestions is an age for the minerals hosted by the Precambrian age rocks, for which there is insufficient data to permit any comments.

It is conceivable that there were four periods of mineralization (beginning with the youngest):

(a) Late Triassic age,
(b) Early Permian-Late Carboniferous age,
(c) Early Carboniferous age, and
(d) Mid to Late Devonian age.

Late Triassic Age

It is believed that the barite and barite-fluorite occurrences spatially related to the Glooscap Fault System could be Late Triassic in age. This is suggested primarily on the basis of the geology of the occurrences located in the Cobequid Highlands. As noted previously, these occurrences are spatially related to north-south and northwest-southeast trending faults. Studies by Donohoe and Wallace (1978) indicate that these faults always offset the Cobequid Fault, while the reverse situation was not observed. They also indicate that these faults accompanied rifting during Late Triassic time. This would preclude a pre-Triassic age for the mineralization and support a Late-Triassic age. It is probable that the heat resulting from volcanism which produced the North Mountain basalt was the driving mechanism that promoted the migration and subsequent precipitation of the ore minerals.

Early Permian-Late Carboniferous Age

With the exception of (14) Bass River, it is suggested that the majority of epigenetic barite, celestite, fluorite and barite-fluorite occurrences hosted by Carboniferous age rocks, are Early Permian-Late Carboniferous in age. This age coincides with the waning stages of the Maritime Disturbance. The following observations are believed to support this suggestion:

(1) No occurrences of barite were reported, nor were any encountered during field investigations, in Triassic age rocks. A large portion of the Triassic exposures along the Walton Shore on the Minas Basin were examined (an area where barite would be most expected to occur because of the abundance of showings in the Carboniferous rocks at this locality) but no barite was observed.

(2) A significant number of occurrences (primarily those south of the Glooscap Fault System) show evidence of post-mineralization movement, such as brecciation, shearing, and off-setting of the mineralized areas (See item 7 in "Other Pertinent Observations and Results", this report).

While it could be argued that the Triassic rocks were chemically inert to the mineralizing solutions, it is suggested that this is unlikely because in some instances the mineralized Carboniferous age Horton Group is petrologically similar to the Triassic sediments. Continued movement along east-northeast and northwest striking faults during the Palisades Disturbance may have been responsible for a large portion of the deformational features observed in the mineral deposits in the western section of the Horton Group and Windsor Group. These same movements resulted in similar striking, unmineralized faults in the Triassic rocks.

Volatiles associated with plutonism and volcanism during Lower Carboniferous and early Upper Carboniferous time may have been instrumental in contributing additional essential ions (Ba, Sr, F) to the solution bearing faults, fissures and sedimentary strata. In the instances where a spatial relationship could be postulated between this igneous activity and mineralization, e.g. the Fisset Brook acid volcanics and the Lake Ainslie deposits, it is possible that decreasing temperatures which followed the termination of igneous activity were responsible for the precipitation of the minerals.

Early Carboniferous Age

Where a syngenetic origin can be demonstrated for deposits hosted by Lower Carboniferous, Windsor Group rocks, mineralization of this age is indicated. This may apply to the Loch Lomond celestite deposits and the McArras Brook barite showing.

Mid and Late Devonian Age

Barite and fluorite mineralization of this age is indicated for those deposits and showings which are spatially and genetically related to the igneous intrusions which accompanied the Acadian Orogeny. These showings include the fluorite deposits in the South Mountain Batholith; the barite deposits at Lake Fletcher, Halifax County; Shenacadie, Cape Breton County; and Nicholsville, Kings County.

If these four ages of mineralization are accurate, it would seem that the greatest portion of barite mineralization took place during Early Permian-Late Carboniferous time. Depending on its origin, i.e. syngenetic or epigenetic, the majority of the celestite mineralization occurred either during Early Carboniferous time or Late Carboniferous-Early Permian time. A mid to late Devonian time is apparent for a large segment of the fluorite mineralization, though Early Permian-Late Carboniferous and Late Triassic time may be equally important as illustrated by the deposits in the Cobequid Highlands and Cape Breton Island.

Some Geological Settings in Nova Scotia and the Significance of These to Potential Barite, Celestite and Fluorite Mineralization

The results of the investigations into the known barite, celestite, and fluorite occurrences in Nova Scotia suggest that a number of geological settings serve as favourable hosts or associations to barite, celestite, and fluorite mineralization. These are:

The Horton Group-Windsor Group Contact

The Horton Group-Windsor Group contact has been recognized in the past as highly favourable because of the localization along this contact of the Walton barite-metallic (Cu-Pb-Zn-Ag) sulphide mine. It is important to note that this deposit is "pipe" shaped (Style C) and directly reflects the high degree of deformation to which the host rocks have been subjected. This style of deposit is unlikely to occur at Horton-Windsor contact locations that are relatively undeformed. In the structurally deformed regions Styles A and B deposits are also encountered, the latter of which is of particular interest in that it has not been actively sought after or recognized in the past. Where Style B deposits occur in quartz sandstone, i.e. barite cemented quartz sandstone, the potential for large, low grade (35-55 per cent) barite deposits is excellent, particularly in the Minas sub-basin area.

It is the writer's opinion that the potential for another Walton type (Style C) deposit in the Minas sub-basin is very good. It can be seen from Figure 200 that a broad gap (where no known occurrences are recorded) exists between the Hilden prospect (No. 17) and the Walton barite mine. The paucity of outcrop and the thick cover of overburden has apparently discouraged exploration in the past. It is felt, however that in view of the ore potential, i.e. the possibility of sulphides associated with the barite, this section of the Horton-Windsor contact deserves closer examination.

Another region viewed favourably by the writer is the Mabou Mines-Finlay Point area, where a number of prominent structural dislocations occur in association with known barite mineralized rocks (Style B) and the Horton-Windsor contact.

Although the Mabou Mines area and the Minas Sub-basin have been singled out as potentially good prospect zones, this should not detract from other locations where the Horton-Windsor contact and known barite deposits occur. These regions include: (a) the Antigonish area, (b) the Detter Creek, Richmond County area, (c) the Yankee Line, Victoria County area, and (d) the Judique-Mabou, Inverness County area.

The Pre-Carboniferous Basement Rocks-Windsor Group Contact

This contact has given favourable results (Loch Lomond celestite deposits), particularly where Windsor Group rocks onlap on to basement highs. Until the recent discovery of barite with this association at Southvale in the Minas sub-basin, the majority of deposits consisted of celestite occurrences and appeared to be confined to the Windsor Basin in Cape Breton Island. The Southvale occurrence illustrates the potential of this association on mainland Nova Scotia.

A similar region which holds promise but has not been investigated for deposits is the Bridgeville area of Pictou County, where barite is known to occur as fissure fillings. In this region, Windsor Group sediments rest unconformably on Silurian and Devonian age metasediments. Here, favourable locations would be where prominent erosional irregularities occur in the Silurian-Devonian rocks beneath the Windsor Group cover rocks. An additional geological feature which lends further support to this area as a good prospect zone is the close proximity of the Glooscap Fault System which traverses the region just to the south. The association of barite and fluorite with this fault system was noted earlier in this report.

Other Windsor Group-pre-Carboniferous basement onlap situations are present in various localities in Nova

Scotia, all of which are worthy of exploratory work for barite and celestite. The host rocks generally belong to the lower Windsor Group, though upper Windsor Group rocks (albeit rarely occurring in an onlap situation) should not be ignored as they have been in the past. The styles of deposits most likely to be found with this association are A, B, D, and F.

The Glooscap Fault System

The spatial relationship between barite and fluorite deposits and this fault system has already been mentioned. It appears that any favourable structures, particularly north-south faults, associated with this fault system hold promise for barite and fluorite. It is interesting to note that almost all occurrences in close proximity to this fault system are hosted by meta-sedimentary rocks of Silurian or older age, suggesting that these may be favoured over igneous rock types and younger sedimentary rocks. An exception is (14) Bass River, which is hosted by Upper Carboniferous age rocks.

Styles of deposits likely to occur with this association are A, B, and possibly C if the geological setting is suitable.

The Upper Carboniferous Rocks

The occurrences examined in these rocks are structurally controlled, all being of the fissure filling type (Style A) with the exception of (14) Bass River (Style B). As previously mentioned, a spatial relationship exists between the Athol-Tatamagouche Synclines and barite-fluorite occurrences in the southern portion of Cumberland County, and in the northern part of Pictou County. Although the significance of this association is not readily apparent, it would be reasonable to consider structural dislocations and brecciated zones within the Athol-Tatamagouche Synclines as potentially favourable to barite mineralization and possibly fluorite mineralization.

Elsewhere in the Upper Carboniferous sediments, the only association with barite deposits that is in evidence is the presence of carbonaceous material (see item 2 in "Other Pertinent Observations and Results", this report) and an anomalously high barium content in the surrounding host rock (Table 2). The low number of occurrences reported to occur in the Upper Carboniferous sediments may reflect the lack of attention paid to these rocks in the past as a potential host to economic quantities of ore. The styles of deposits most likely to be found in these rocks are A, B, and possibly E. Although Style E has not been reported in the Upper Carboniferous rocks, grey shaly members should be carefully scrutinized for barite deposits similar to that at (6) McArras Brook. At this location a synsedimentary barite deposit is hosted by a thin grey shaley unit bound stratigraphically above and below by a thick sequence of red sandstone and siltstone.

The Upper Windsor Group Rocks

This group of rocks has been almost totally disregarded in the past because of its position in the stratigrapic column (since the discovery of the Walton Mine in the 1940's almost all exploratory activity was directed at the Lower Windsor Group). Yet, in the past few years significant discoveries have been made in these rocks, e.g. (6) McArras Brook (barite), and (24) Urbania (barite). In addition to the discovery of new occurrences, stratigraphic and faunal studies of the host rocks at (20) Middle Stewiacke and (13) Sydney River indicate these showings to be hosted by the Upper Windsor Group.

Two of the occurrences in the Upper Windsor Group (Middle Stewiacke and Urbania) are structurally controlled (Styles A and C) and the remainder are stratigraphically controlled (Style E). Styles A and C may occur in any structurally deformed Upper Windsor rocks, although the presence of an unconformity and/or a major fault system nearby would increase the probability of an occurrence attaining dimensions of economic importance. Style E deposits of the replacement type require more study to determine what factors other than rock type, porosity and permeability are responsible for the localization of the ore minerals. However, the present information suggests that careful examination of this horizon in the C-Subzone of the Upper Windsor Group is warranted elsewhere in Nova Scotia.

Synsedimentary deposits such as the one at McArras Brook would be dependent upon the physico-chemical conditions at the time of deposition. The nature of the host rocks at this occurrence suggest an estuarine depositional environment. Rocks of the Upper Windsor Group suggesting a similar depositional environment could well be favourable hunting grounds for such a deposit.

The Pre-Carboniferous Metamorphic Rocks

This group of rocks appear to be relatively unimportant as hosts to barite and fluorite, with the exception of those near the Glooscap Fault System. Excluding these, only three occurrences, (33) Lake Fletcher, (49) Corney Brook, and (51) Nicholsville of those investigated, are hosted by pre-Carboniferous rocks. All three are of the fissure-filling type (Style A), and their proximity to igneous intrusions younger than the host rocks suggests there may be a genetic relationship. Because these occurrences are all of the fissure-filling type, their favourability as prospects is restricted to structurally deformed areas where sizable fractures and faults are prominent features.

The "Granitic" Rocks

With the exception of one barite showing at (12) Shenacadie, all the occurrences examined in these rocks consist of fluorite deposits and are found in the South Mountain Batholith. The showings are of the fissure-filling type (Style A) and undoubtedly represent the hydrothermal phase of this differentiated batholith. Since the hydrothermal phase occurred late in the batholith's history it would not be unusual to find fluorite in tension fractures throughout the batholith. However, it is likely that the hydrothermal liquids had their origin at the centres of this igneous activity, consequently these central areas (of which the New Ross-Leminster district is one), would have more potential than the areas cicumferential to them.