GENERAL GEOLOGY AND REGIONAL SIGNIFICANCE OF THE GRANDYS LAKE AREA (110/15), NEWFOUNDLAND

by

Lesley Chorlton

INTRODUCTION

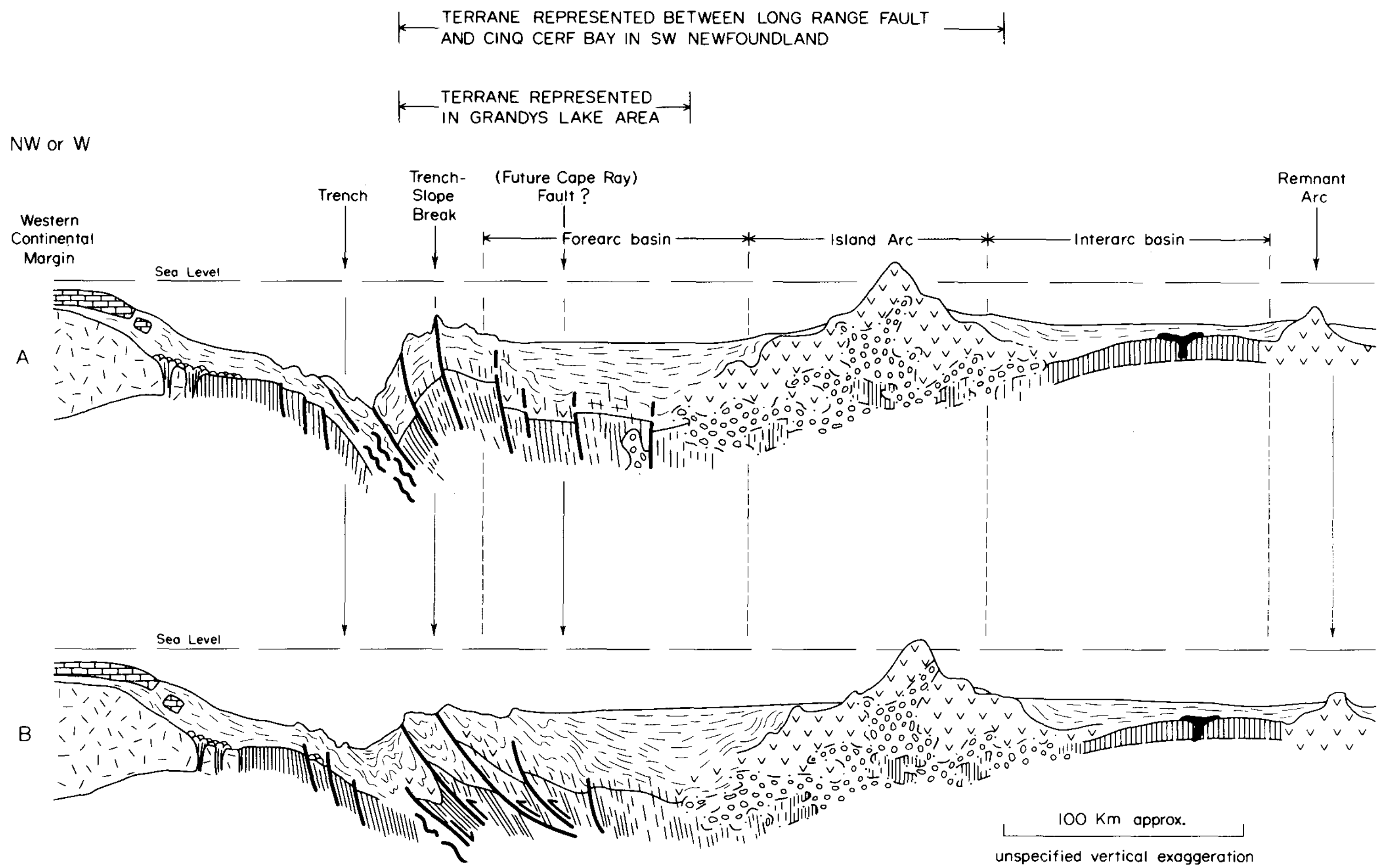
New information provided during the recent mapping project (Chorlton, 1978, 1980a, 1980b, 1980c; Dallmeyer, 1979; Chorlton and Dingwell, 1981) has lead to a re-evaluation of the significance of southwestern Newfoundland in the plate tectonic development of the Newfoundland Appalachians. A preliminary attempt is made here to define geological components in southwestern Newfoundland, especially in the Grandys Lake area, and to assess them in the context of the revised regional model.

The Cape Ray Fault, which traverses diagonally across the Grandys Lake area, was previously considered a cryptic suture juxtaposing two Precambrian continental basement complexes, the 'Long Range Gneiss' and the 'Port aux Basques Gneiss' (Brown, 1973). The axial region of the Central Mobile Belt (Williams, 1964), a zone characterized by Early Paleozoic oceanic crust overlain by island arc and marine sedimentary sequences, was thought to be pinched out along this fault to the northeast of the area (Kennedy, 1976; Brown and Colman-Sadd, 1976).

Recent work in the La Poile (110/9) and La Poile River (110/16) map areas challenges this interpretation, and has revealed that the area southeast of the Cape Ray Fault in those areas is underlain by an Ordovician metavolcanic pile with island arc affinities grading laterally into a probable marine metasedimentary sequence with associated amphibolite. These rock assemblages are presently assigned to the Bay du Nord Group (Cooper, 1954; modified by Chorlton, 1980b) and the time equivalent La Poile Group (Cooper, 1954; redefined by Chorlton, 1978). The metasedimentary rocks and associated amphibolite continue westwards into the Grandys Lake (110/15) map area, and can be correlated with the 'Port aux Basques Gneiss' of Brown (1975), previously considered Precambrian continental basement. Prevolcanic mafic plutonic rocks, especially those underlying the Blue Hills of Couteau southeast of the Cape Ray Fault (Chorlton, 1980a), are partly composed of ophiolitic high level gabbros (G.R. Dunning, personal communication, 1981), representing segments of Lower Paleozoic oceanic crust. North of the Cape Ray Fault in the Grandys Lake area, ophiolitic rocks of the Lower Paleozoic Long Range Mafic-Ultramafic Complex (Brown, 1976) are now also interpreted as the oldest rocks exposed. Therefore, the Cape Ray Fault can no longer be referred to as a cryptic suture between two continental basement terranes. Rocks typical of the axial region of the Central Mobile Belt, although more highly deformed and metamorphosed, actually underlie much of the Grandys Lake area on both sides of the fault. However, lithologies now exposed on either side contrast somewhat. In plate tectonic jargon, the northwestern terrane might be the ophiolite-based, plutonically intruded basement to either part of a 'subduction complex' or a 'forearc basin' (*cf.* Dickinson, 1977; Seely *et al,* 1974, Hussong and Uyeda, 1981), and the southeastern terrane a sedimentary 'forearc basin' underlain by largely mafic rocks (Figures 1 and 2, Table 1). Both terranes are part of an 'arc-trench system', the volcanic 'arc' of which is represented by the Bay du Nord-La Poile Group volcanic centre exposed southeast

Figure 1: Suggested relationships among pretectonic lithostratigraphic units (1, 2, 3, on map) in southwest Newfoundland before collision of arc-trench gap with North American continent.

1A: *Model reflecting early block faulting and subsidence in arc-trench gap*
1B: *Model reflecting imbrication above subduction zone*

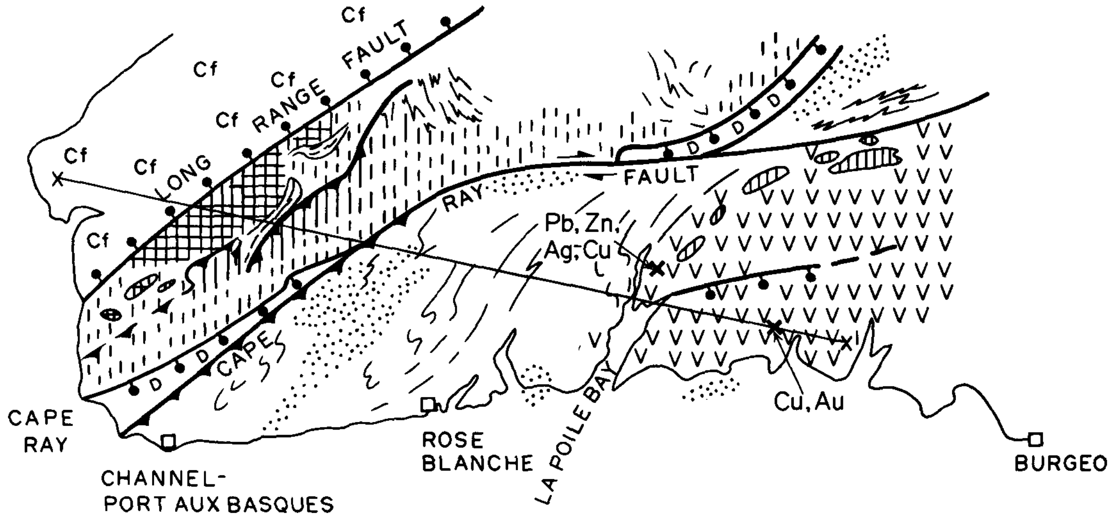


EXPLANATION

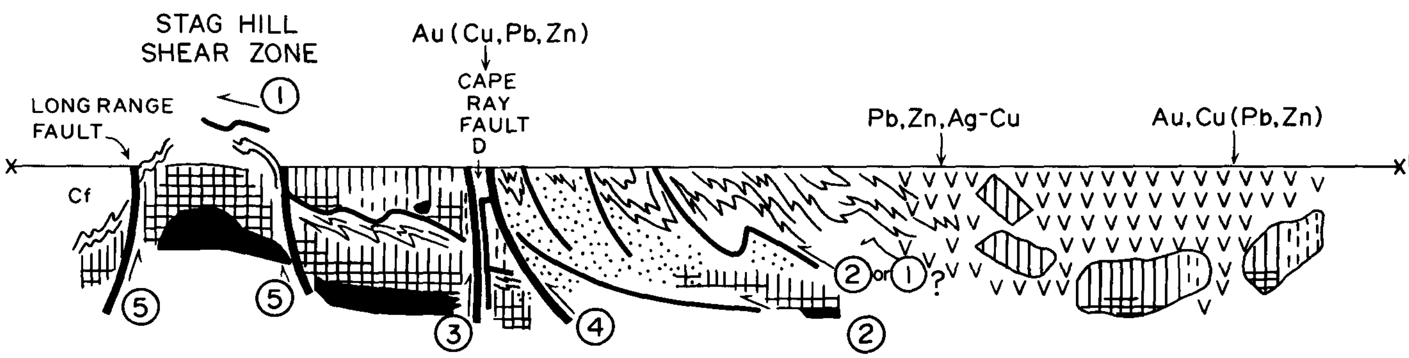
- Grenvillian continental crust
- Carbonate bank
- Clastic sedimentary rocks
- Island arc volcanic rocks including earliest predominantly mafic, subduction related volcanic rocks in fore-arc area
- Oceanic crust
- Oceanic crust permeated by tonalite, quartz diorite, and quartz gabbro which also intrudes overlying volcanic and sedimentary rocks
- Subvolcanic calcalkaline rocks of central arc including tonalite, granophyre, diorite, gabbro, pyroxenite. Some intrusions similar *to tonalite and quartz diorite above*

Figure 2: Approximate distribution of ophiolitic rocks and derivative amphibolite, and Ordovician metasedimentary and island arc metavolcanic, subvolcanic, and volcaniclastic rocks in southwest Newfoundland.

a



b, scale expanded from a



EXPLANATION

- Carboniferous sedimentary rocks . . . . Cf
- Devonian volcanic and sedimentary rocks . . . . DDD
- Ordovician metasedimentary rocks, structural trends indicated . . . .
- Ordovician island arc metavolcanic, subvolcanic, and volcaniclastic rocks . . . . V VV
- Fault, movement and relative stage indicated . . . . (4)
- Thrust fault (may have sited later movement) . . . .
- Block fault . . . .

OPHIOLITIC ROCKS

- High level gabbro, diabase, basalt . . . .
- High level gabbro, diabase, basalt, engulfed by tonalite . . . .
- Layered, cumulate Ol-bearing metagabbro . . . .
- Massive ultramafic rocks . . . .
- Amphibolite of probably ophiolitic origin . . . .

of the Grandys Lake map area.

GENERAL GEOLOGY

The effects of early regional deformation and metamorphism are presently the most convenient frame of reference for outlining the geological history of this area. Therefore, these effects have here been used to separate the geological development into three stages prior to Carboniferous sedimentation in the Codroy Valley to the west. However, it is emphasized that the sequence of tectonic events was not necessarily synchronous across the entire area. Present tectonic models for the Newfoundland Appalachians involve southeasterly-dipping subduction followed by the northwesterly-directed thrusting which finally resulted in ophiolite obduction. According to these models, the earliest effects of obduction-related compressive deformation is envisaged as progressively younger toward the southeast (Table 1). It is conceivable that the early stages of thrusting in the northwest may have overlapped with the latest stages of deposition in the forearc and arc areas to the southeast (*i.e.* Figure 1b). The earliest deformation recorded in rocks exposed on the south side of the Cape Ray Fault affected the radiometrically dated Middle(?) Ordovician volcanic rocks southeast of the map area.

STAGE 1

The first stage involved the generation of the oldest rocks in the area, the ophiolitic Long Range Mafic-Ultramafic Complex (1a,b,c,d,e, part of 3b) and the deposition of overlying sedimentary rocks. The sedimentary rocks in the northwest consisted of graywacke, shale, limestone, marl, quartzitic sandstone, ferrugenous chert, tuffaceous and possibly other volcanic-related rocks (2a,b,c), which are now highly metamorphosed. Mafic metavolcanic rocks (1d) are also associated with these metasedimentary rocks. A sequence of graywacke and shale (3a) with minor interbedded basalt (part of 3b) in the southeast, belonging to the modified Bay du Nord Group (tentatively retained name), may have postdated the deposition of some of the rocks of unit 2 and overlapped in time with stage 2 in the northwest.

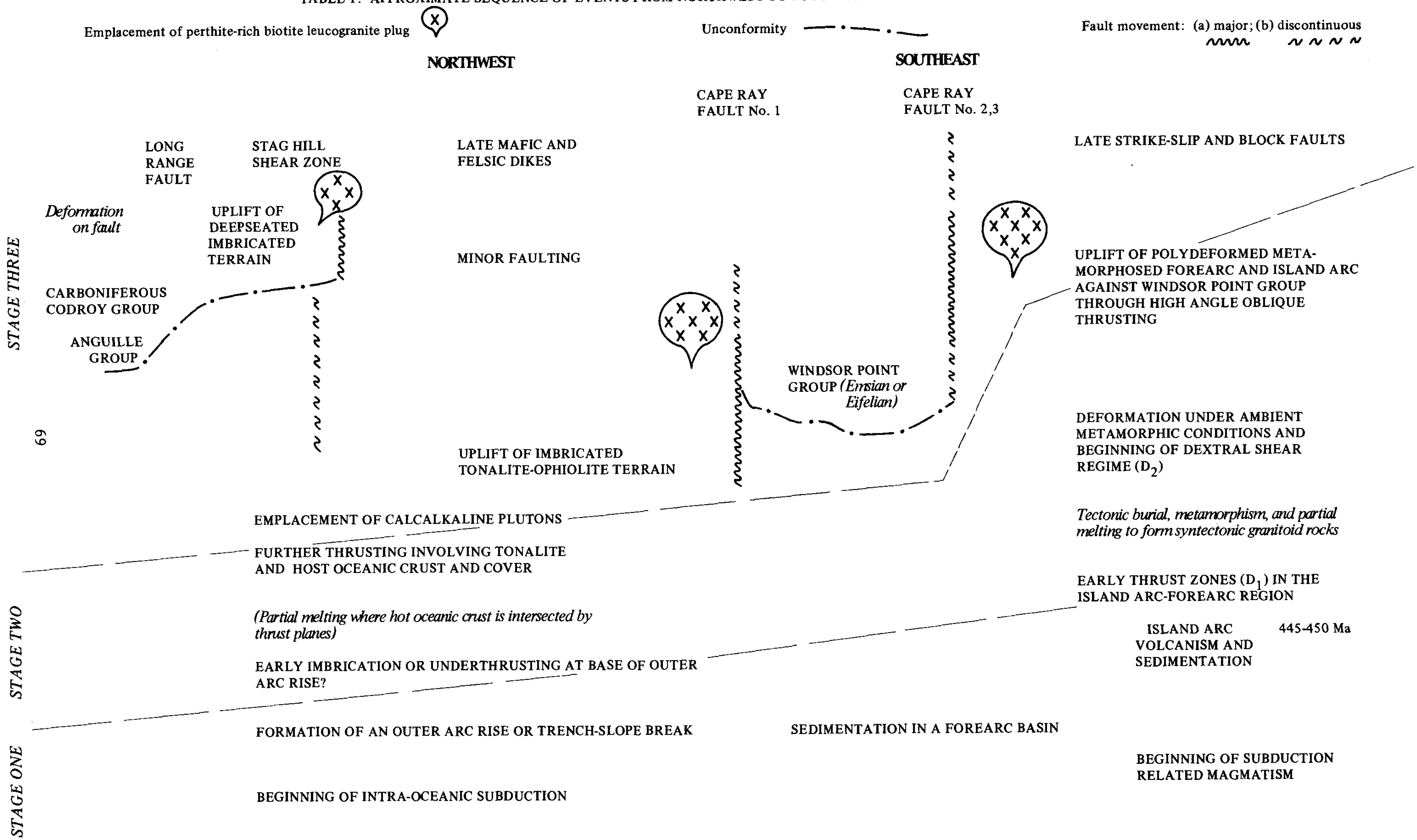
STAGE 2

The second stage involved early, intense, polyphase regional deformation which accompanied westerly or northwesterly directed imbrication and thrusting (Figure 2b, fault movements 1 and 2):

In the northwest, the lower parts of the ophiolitic crust were locally intersected by thrust planes (Figure 2b, fault movement 1). These rocks, which may have initiated their deformation history at high temperatures, presumably became partially hydrated during thrusting. Consequently, they would have been either retrograded or partially melted depending on whether the temperature maintained was lower or higher than the solidus (beginning of partial melting) temperature. Partial melting would explain the presence of the voluminous tonalite (4) and later magmas that intruded the ophiolitic rocks and their cover. Megacrystic quartz monzonite (6) succeeded these early granitoid rocks. These intrusions and their hosts were penetratively deformed and metamorphosed. Further imbrication and repetition of localized thrusting may have caused the superposition of a dynamothermal aureole in the tonalite and its inclusions (4b,2c,1d) sited within a shear zone underneath the thrust sole (now eroded) in the north-central part of the map area.

In the southeast, early thrusting (Figure 2b, fault movement 2 and/or 1?) resulted in tectonic burial and metamorphism, accompanied by local migmatization and sheetlike emplacement

TABLE 1: APPROXIMATE SEQUENCE OF EVENTS FROM NORTHWEST TO SOUTHEAST IN SOUTHWEST NEWFOUNDLAND



LEGEND

CARBONIFEROUS

12	Sedimentary rocks, largely alluvial fan deposits of the Codroy Group.

DEVONIAN OR YOUNGER

11	Late mafic and felsic dikes (many not shown)
10	Pink, perthite-rich biotite leucogranite plutons with hypersolvus and subsolvus phases.
9	Pink, largely fine but locally medium grained, two feldspar leucogranite, local tuffisite.

DEVONIAN

8	WINDSOR POINT GROUP: Strongly bimodal volcanic and volcaniclastic rocks with associated sedimentary rocks.
7	Quartz diorite to megacrystic granite with many tonalite and amphibolite screens.

SILURIAN

6	Deformed, megacrystic quartz monzonite, locally augen gneiss, minor megacryst poor patches.
5	**ROSE BLANCHE GRANITE:** Schistose to gneissic tonalite, granodiorite, granite with many country rock screens.

ORDOVICIAN and possibly older

4	Foliated tonalite, granodiorite and granite with abundant rafts, inclusions, or country rock screens; **4a**, biotite tonalite to trondhjemite; **4b**, inclusion-rich, foliated to gneissic garnetiferous biotite tonalite; **4c**, garnetiferous biotite granodiorite to tonalite, gneissic lit par lit injections and sheets; **4d**, pink, foliated to gneissic granite.
3	**Modified BAY DU NORD GROUP: 3a**, Mainly semipelitic schist, migmatite; **3b**, amphibolite.
2	Metasedimentary rocks: **2a**, Largely semipelitic paragneiss, migmatite; **2b**, marble; **2c**, assorted metasedimentary xenoliths.
1	**LONG RANGE MAFIC-ULTRAMAFIC COMPLEX: 1a**, ultramafic rocks; **1b**, layered cumulate metagabbro; **1c**, massive, vari-textured metagabbro, metadiabase, and plagiogranite; **1d**, mafic metavolcanic rocks and dikes; **1e**, undivided amphibolite.

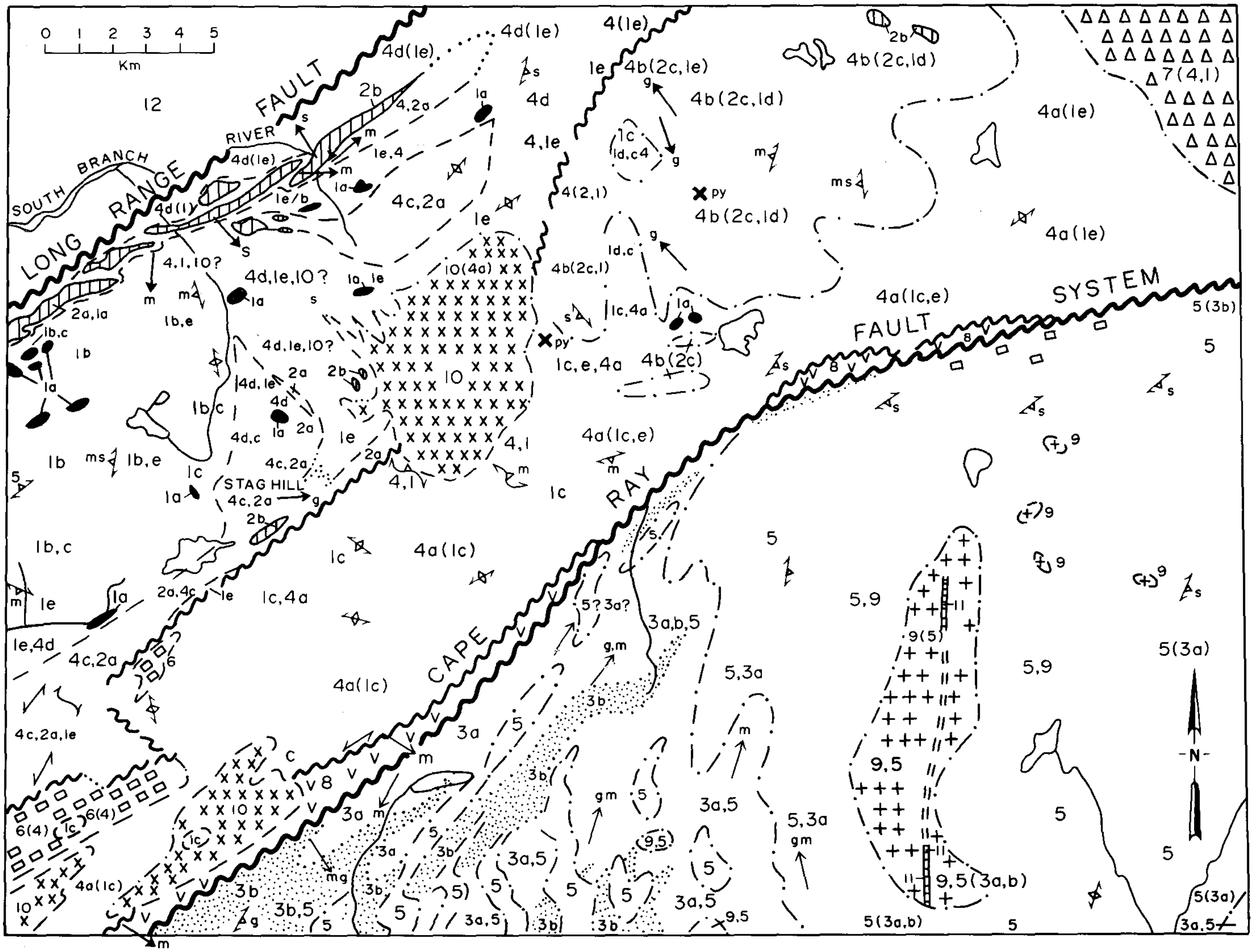


FIG. 3 GRANDYS LAKE 11-O/15

of the Rose Blanche Granite (5). The thickest granitoid units were probably generated slightly deeper in the metamorphic pile. After emplacement, these granitoid rocks were moderately to intensely deformed under the prevailing metamorphic conditions.

STAGE 3

The third stage initially involved the emplacement of a quartz diorite-megacrystic granite intrusion (7), which postdated the penetrative deformation of the early granitoid rocks (4) in the north. Subsequent uplift of the northwest part of the Grandys Lake area along the Cape Ray Fault system (Figure 2b, fault movement 3), and either sinistral or dextral strike-slip movement along the fault, was accompanied or followed by the eruption and deposition of strongly bimodal volcanic and associated sedimentary rocks of the Windsor Point Group (8). Subsequently, the Bay du Nord Group (3) and Rose Blanche Granite (5) were uplifted obliquely against the Windsor Point Group along the fault zone and the tonalite-ophiolite terrane north of the fault by northwesterly directed, high angle thrusting (Figure 2b, fault movement 4). This was followed by, or possibly accompanied, the emplacement of the late leucogranite plutons (9, 10) and mafic and felsic dikes (11).

CARBONIFEROUS

The Carboniferous sedimentary rocks northwest of the Long Range Fault belong to the Anguille Group (Tournaisian?, possibly older), the Codroy Group (Middle to Upper Visean), and the Barachois Group (Westphalian A) (Baird and Cote, 1964). The Codroy and Barachois Groups were deposited after emplacement of the youngest plutonic rocks in the terrane southeast of the Long Range Fault, but it is possible that the Anguille Group was deposited before the cessation of plutonism. Uplift of a strip of the pre-Carboniferous ophiolitic terrane along the present Long Range Fault affected the adjacent Carboniferous rocks (Figure 2b, fault movement 5). This activity may have been accompanied by dextral strike-slip movement and block faulting on smaller, reactivated faults and shear zones.

SUMMARY

The geological development of the Grandys Lake and surrounding areas reflects the evolution of the proto-Atlantic Ocean from the earliest stages of intra-oceanic closure to cratonization of the oceanic terrane (and inferred collision of an arc-trench gap with the North American continent). Primarily oceanic crust rapidly attained a continental character by means of subduction-related island arc volcanism and plutonism which evolved into syntectonic/metamorphic granitoid emplacement. This was followed by block and wrench fault activity, the formation of Devonian fault-controlled sedimentary basins and bimodal volcanic activity, and late stage granite emplacement.

Easterly or southeasterly-directed subduction began to the west or northwest of the terrane represented in this area, and resulted in the development of the Central Newfoundland island arc system. Rocks belonging to one of the volcanic centres of the arc are exposed southeast of the area near La Poile Bay. An 'outer arc' rise in the northwest may have resulted in the formation of a forearc sedimentary basin in front of the volcanic arc. The forearc sedimentary sequence contains interbedded mafic volcanic rocks. In the northwest part of the area, early imbrication and underthrusting of oceanic crust and its sedimentary cover, either within the upper slab or in an accretionary wedge, may have been accompanied by the generation of synmetamorphic tonalite within the thrust complex, perhaps while the last stages of sedimentation and island arc activity continued in the southeast.

Upon complete and final collision with the North American continental margin, ophiolite imbrication continued (or began) in the northwest, and thrusting to the west or northwest affected the forearc and arc terrane in the southeast. This caused tectonic burial and associated medium pressure, medium to high grade regional metamorphism, accompanied by the generation of synkinematic granodiorite and tonalite in the forearc and arc areas. Further deformation under amphibolite facies conditions in this terrane apparently reflects the beginning of a sinistral or dextral ductile shear system. In the northwest part of the area, a megacrystic quartz monzonite and calc-alkaline diorite/ granite body was emplaced before uplift of parts of the northwestern terrane along the Cape Ray Fault.

The eruption and deposition of bimodal volcanic and sedimentary rocks of the Windsor Point Group occurred within an 'intracratonic' basin controlled by block and wrench faulting along the initial Cape Ray Fault. Deposition was halted by oblique, high angle thrusting of the older, deformed rocks in the southeast against the Windsor Point Group along the southeast side of the Cape Ray Fault, and continued strike-slip movement. Potassic granite plugs and mafic and felsic dike swarms signify the last stages of magmatic activity.

Carboniferous sedimentation largely postdated this activity. However, the initiation of the oldest parts of the sedimentary basin associated with the base of the Anguille Group may have coincided with movement on the Cape Ray Fault system (Knight, in preparation). The Carboniferous rocks were affected by late uplift along the Long Range Fault, and by continued stress resolved by minor folding and faulting.

MINERAL POTENTIAL

Of three established mineral prospects in southwest Newfoundland (Figure 2), two are sited in the Middle(?) Ordovician island arc southeast of the Grandys Lake area. The third, a gold prospect, is located in the Cape Ray Fault zone at the southwest corner of the Grandys Lake area.

The Strickland Prospect (massive Pb-Zn-Ag and disseminated Cu) formed in a marine environment near the northwestern margin of the Middle Ordovician volcanosedimentary pile at the edge of a small starved marine trough, and in the vicinity of a subvolcanic granitoid stock and dike system. It has been described in detail by Cooper (1940a, 1940b, 1954), Swinden (1981), and others. The sulphides are associated with felsic volcanic bands interlayered with largely volcaniclastic rocks. The trough is characterized by graphitic phyllite with tuffaceous graywacke schist and volcanic-derived granule conglomerate interbeds. The showings and their hosts are polydeformed and metamorphosed to lower amphibolite or upper greenschist facies, further sheared and partly retrogressed. Since they were discovered in 1935, the Strickland Prospect and several showings in the same volcanic horizon have been the focus of recurrent regional exploration and mineral assessment, most recently by Falconbridge Nickel Mines Ltd.

The Chetwynd Prospect (Cu-Au) occurs in a more massive, either shallow marine or subaerial, part of the volcanic edifice to the southeast. Best accounts of the mineralization are by Cooper (1940b, 1954), Pouliot (1957), and Swinden (1981). Disseminated and vein type mineralization is sited in one of two highly sheared and altered felsite bands which may have originated either as extrusive rhyolite (ash?)flows or as subvolcanic rhyolite dikes or sills. The surrounding volcanic terrane comprises mafic to intermediate flows, tuffs, hypabyssal rocks, and felsic tuffs, north of which a prominent conglomeratic sedimentary horizon is exposed. All are now deformed and metamorphosed under greenschist facies conditions. Three shallow shafts were sunk in and adjacent to the northernmost, cupriferous felsite band between 1903 and 1905 (Cooper, 1940b). A shallow trench was later cut across the most productive zone. Pyrite, chalcopyrite, tennantite, bornite, chalcocite, covellite, malachite, barite, fluorite, and pyrophyllite occur in the mine dump and around the collar of the main shaft. The fee simple grant which encloses the area of the shafts was recently declared undeveloped by the Government of Newfoundland and Labrador, and will soon be open for staking.

The Cape Ray gold prospect consists of several showings of gold associated with base metal sulphides, and was described by Bucknell *et al.* (1980). In general, the showings are vein occurrences sited in (i) the highly sheared Windsor Point Group and/or in mylonitized Bay du Nord amphibolitic gneisses which occur along a shear zone of the Cape Ray Fault system, and (ii) in the Windowglass Hill Granite adjacent to the southwest corner of the Grandys Lake area. The Windowglass Hill Granite is considered a subvolcanic granophyre or rhyolite dome, genetically related to the strongly bimodal volcanic rocks of the Windsor Point Group. Significant factors relating to the mineralization may be: (1) the favourable precipitation environments offered by the Devonian volcanic and metasedimentary (locally graphitic) rocks of the Windsor Point Group (Bucknell *et al.*, 1980), (2) the oceanic to subduction related affinities of the underlying ophiolite-founded arc-trench gap traversed by the Cape Ray Fault, and (3) hydrothermal activity associated with the fault system. The Cape Ray property, part of a mineral concession granted to Brinex, has been the object of intensive exploration and assessment by Riocanex Ltd. (Northern Miner, 1977, 1978, 1980).

Recent re-interpretation of the geology of southwest Newfoundland suggests a greater mineral potential for this area than previously envisaged. Cyprus type massive sulphide (Fe-Cu) deposits (Hutchinson, 1973, 1980; Strong, 1974) are potentially present in hypabyssal and extrusive mafic volcanic parts of the ophiolite, *i.e.*, massive metagabbro and metadiabase (1c) to mafic metavolcanic and metasedimentary rocks (1d,e, 2c). Besshi or keislager type massive sulphides (Cu-Zn?) are also potentially associated with graywackes and mafic volcanic rocks in arch-trench gaps (Sawkins, 1976; Hutchinson, 1980), and could conceivably be hosted by metasedimentary rocks and interlayered amphibolites of the forearc basin, *i.e.*, the modified Bay du Nord Group (3a,b) or the metasedimentary and associated metavolcanic rocks (2,1d,1e) northwest of the Cape Ray Fault. Alternatively, early arc volcanics, potentially hosting the 'volcanogenic primitive type' (Zn-Cu) massive sulphides (Hutchinson; 1980), could also be considered possible analogues for the mafic metavolcanic rocks in either of the above units, since their affinities have not been investigated. Massive sulphide occurrences could conceivably be responsible for highly sheared, altered sulphide showings (Figure 3) where tonalite-intruded, high level gabbro and metadiabase (4a,1c) switches abruptly to tonalite-intruded, metasedimentary and mafic metavolcanic rocks (4b,2c,1d). Any massive sulphide mineralization in this region may have been affected by magmatic recycling during the generation of abundant late granitoid rocks and possibly selectively remobilized or concentrated by hydrothermal activity along several generations of shear zones which characterize the area.

Northwest of the Cape Ray Fault, several quartz diorite to quartz monzonite and granite plutons may have potential for porphyry copper mineralization (*cf.* Strong, 1980). The age of these plutons is uncertain, but they could range from Middle Ordovician to Early Devonian based on field relations. One such pluton (7) in the northeast corner of the Grandys Lake area shows evidence for late magmatic hydrothermal alteration accompanied by orthoclase porphyroblast development. Several similar, post-tonalite, pre-Windsor Point Group, granitoid plutons, some with minor mineralization, have been observed in the northwestern terrane northeast of the Grandys Lake area (Herd and Dunning, 1979; Kean and Jayasinghe 1980; G.R. Dunning, personal communication, 1981) and southwest of the area (D. Wilton and C.B. Mackenzie, personal communication, 1979). This suite may therefore be common in the northwestern terrane, and might be intersected at the present erosion surface at higher emplacement levels elsewhere, since the Devonian vertical movements cannot be expected to have affected the whole terrane homogeneously. Granitoid-hosted porphyry mineralization is known in similar settings elsewhere in the Appalachian system (Hollister *et al.*, 1974). Evidence of hydrothermal activity, ranging in age from that associated with the early thrust zones (Ordovician) to that associated with the Cape Ray Fault and other late structures (Devonian), is common in this terrane. Hydrothermal activity which encountered coeval mineralized granitoid rocks may have produced significant mineral enrichment.

ACKNOWLEDGEMENTS

Steve Colman-Sadd, Ron Smyth, and Scott Swinden are thanked for their constructive criticism, advice, and other comments; in particular, Steve regarding plate-tectonics, Scott regarding economic geology, and Ron for encouraging me to write this manuscript. This report was reviewed by Steve Colman-Sadd, Ron Smyth, and Scott Swinden.

REFERENCES

Baird, D.M. and Cote, P.R.
1964: Lower Carboniferous sedimentary rocks in southwest Newfoundland and their relationships to similar strata in western Cape Breton Island. Canadian Institute of Mining and Metallurgy Bulletin, Volume 57, pages 509-520.

Brown, P.A.
1973: Possible cryptic suture in southwest Newfoundland. Nature, Physical Science, Volume 245, No. 140, pages 9-10.

1975: Basement-cover relations in southwest Newfoundland. Ph.D. thesis, Memorial University of Newfoundland, 221 pages.

1976: Ophiolites in southwest Newfoundland. Nature, Physical Science, Volume 264, pages 712-715.

Brown, P.A. and Colman-Sadd, S.P.
1976: Hermitage Flexure: Figment or fact? Geology, Volume 4, pages 561-564.

Bucknell, W.R., Mackenzie, C.B. and Wilton, D.H.C.
1980: Geology of the Cape Ray gold deposit, southwestern Newfoundland. GAC-MAC Joint Annual Meeting, Program with Abstracts, Volume 5, page 43.

Chorlton, L.B.
1978: Geology of the La Poile area (110/9), Newfoundland. Newfoundland Department of Mines and Energy, Mineral Development Division, Report 78-5, 14 pages.

1980a: Notes on the geology of Peter Snout (11P/13, west half), Newfoundland. Newfoundland Department of Mines and Energy, Mineral Development Division, 9 pages to accompany Map 80201.

1980b: Geology of the La Poile River area (110/16), Newfoundland. Newfoundland Department of Mines and Energy, Mineral Development Division, Report 80-3, 86 pages.

1980c: Grandys Lake (110/15), west half. *In* Current Research. *Edited by* C.F. O'Driscall and R.V. Gibbons. Newfoundland Department of Mines and Energy, Mineral Development Division, Report 80-1, pages 74-78.

Chorlton, L.B. and Dingwell, D.B.
1981: Grandys Lake (110/15), Newfoundland. *In* Current Research. *Edited by* C.F. O'Driscoll and R.V. Gibbons. Newfoundland Department of Mines and Energy, Mineral Development Division, Report 81-1, pages 57-69.

Cooper, J.R.
1940a: Lead-zinc-silver and copper mineralization in the Bay du Nord series: general features. Newfoundland Department of Mines, unpublished report, 13 pages.

1940b: Cinq Cerf. *In* Copper deposits of Newfoundland, *by* G.V. Douglas, D. Williams, D.N. Rove, et al. Geological Survey of Newfoundland, Bulletin 20, pages 144-145.

1954: The La Poile-Cinq Cerf map area, Newfoundland. Geological Survey of Canada, Memoir 254, 62 pages.

Dallmeyer, R.D.
1979: Geochronology - Insular Newfoundland mapping. Newfoundland Department of Mines and Energy, Mineral Development Division, unpublished progress report for 6/1/79 - 11/1/79, 57 pages.

Dickinson, W.R.
1977: Tectono-stratigraphic evolution of subduction-controlled sedimentary assemblages. *In* Island Arcs, Deep Sea Trenches, and Back-Arc Basins. *Edited by* M. Talwani and W.C. Pitman III. Published by Lithocrafters Inc. (Ann Arbor, Michigan), pages 33-40.

Herd, R.K. and Dunning, D.R.
1979: Geology of the Puddle Pond map area, southwestern Newfoundland. *In* Current Research, Part A, Geological Survey of Canada, Paper 79-1A, pages 305-310.

Hollister, V.F., Potter, R.R. and Barker, A.L.
1974: Porphyry-type deposits of the Appalachian Orogen. Economic Geology, Volume 69, pages 618-630.

Hussong, D.M. and Uyeda, S.
1981: Tectonics in the Mariana Arc: results of recent studies, including DSDP Leg 60. *In* Geologie des Marges Continentales, 26 Gong. Geol. Paris. *Edited by* G.P. de Saint Maur. Oceanologica Acta, Colloque 3, pages 203-212.

Hutchinson, R.W.
1973: Volcanogenic sulphide deposits and their metallogenic significance. Economic Geology, Volume 68, pages 1223-1243.

1980: Massive base metal sulphides as guides to tectonic evolution. *In* The continental crust and its mineral deposits. *Edited by* D.W. Strangway. Geological Association of Canada, Special Paper 20, pages 659-684.

Kean, B.F. and Jayasinghe, N.R.
1981: Geology of the King George IV map area, (12A/4), Newfoundland. *In* Current Research. *Edited by* C.F. O'Driscoll and R.V. Gibbons. Newfoundland Department of Mines and Energy, Mineral Development Division, Report 81-1, pages 32-39.

Kennedy, M.J.
1976: Southeastern margin of the northeastern Appalachians: late Precambrian orogeny on a continental margin. Geological Society of America Bulletin, Volume 83, pages 3083-3090.

Knight, I.
1981: Geology of the St. George sub-basin, western Newfoundland.

Newfoundland Department of Mines and Energy, Mineral Development Division, Memoir in preparation.

Northern Miner,
1977: Riocanex discovers gold in SW Newfoundland. Northern Miner, July 28, 1977, pages 1 and 2.

1978: Rio Algom building reserves on Newfoundland gold ground. Northern Miner, November 16, 1978, pages 1 and 8.

1980: Rio Algom starts drilling on Cape Ray gold bet. Northern Miner, July 24, 1980, page 26.

Pouliot, G.
1957: The geology and mineral deposits of the Cinq Cerf River map area. Buchans Mining Company, unpublished report, 35 pages plus maps and diagrams.

Sawkins, F.J.
1976: Massive sulphide deposits in relation to geotectonics. *In* Metallogeny and plate tectonics. *Edited by* D.F. Strong. Geological Association of Canada, Special Paper 14, pages 221-240.

Seely, D.R., Vail, P.R. and Walton, G.G.
1974: Trench-slope model. *In* The geology of continental margins. *Edited by* C.A. Burke and C.L. Drake. Published by Springer-Verlag (New York), pages 249-260.

Strong, D.F.
1974: Plate tectonic setting of Appalachian-Caledonian mineral deposits as indicated by Newfoundland examples. Society of Mining Engineers, AIME, Transactions, Volume 256, page 121-128.

1980: Granitoid rocks and associated mineral deposits of Eastern Canada and Western Europe. *In* The continental crust and its mineral deposits. Edited by D.W. Strangway. Geological Association of Canada Special Paper 20, pages 741-769.

Swinden, H.S.
1981: Economic geology of the Western Hermitage Flexure, Newfoundland. *In* Current Research. *Edited by* C.F. O'Driscoll. Newfoundland Department of Mines and Energy, Mineral Development Division, Report 81-1, pages 80-95.

Williams, H.
1964: The Appalachians in northeastern Newfoundland: A two-sided symmetrical system. American Journal of Science, Volume 26, pages 1137-1158.