CAPE RAY FAULT ZONE SW NEWFOUNDLAND

Map produced by **Benoît Dubé and Kathleen Lauzière, 1995**

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Quebec Geoscience Center (CGQ)

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2963-4
GEOLOGICAL SURVEY OF CANADA
COMMISSION GÉOLOGIQUE DU CANADA
1995

INTRODUCTION

The Cape Ray Fault Zone, located in southwestern Newfoundland, is a major reverse-oblique fault zone of Late Silurian to Early Devonian age developed at the boundary between the Windsor Point Group (WPG) to the NW and the Port aux Basques Gneiss (PABG) to the SE.

From 1989 to 1995, the Quebec Geoscience Centre of the Geological Survey of Canada conducted a detailed geological and metallogenic study along a 60 km long segment of the Cape Ray Fault Zone (Dubé, 1990, Dubé et al., 1991, 1992,1993, 1996; Dubé and Lauzière, in press A-B). The results are summarized below.

ROCK UNITS AND AGE DATING

The PABG includes quartzo-feldspathic gneisses and mylonite of the Grand Bay Complex (GBC) in the SW part of the map, and paragneisses and schists of the Port aux Basques Complex (PBC) in the NE portion of the map. Amphibolitic rocks are locally present in both units. All of these rocks have been variably metamorphosed to at least amphibolite grade. The Rose Blanche Granite, to the NE, intrudes the PABG. It is tonalitic to granodioritic and is typically strongly foliated. It has undergone at least part of the deformation recognized in the PABG. The WPG is subdivided into a volcanic-dominated sequence to the NW and a sediment-dominated sequence to the SE. A black rhyolite at the base of the WPG yielded an age of 453Ma +5/-4Ma (Dubé et al., 1996). The sedimentary pile is intruded by gabbroic sills dated at 424 +4/-3 Ma and is intruded by the sub-volcanic Windowglass Hill granite dated at 424 ± 2Ma (Dubé et al., 1996). The Cape Ray Igneous Complex (CRIC) crops out NW of the WPG and comprises the Cape Ray tonalite, dated at 469 ± 2Ma, a K-feldspar megacrystic phase of the CRIC, dated at 488 ±3 Ma and remnants of the Long Range Mafic-Ultramafic Complex (Dubé et al., 1996). Although the contact between the CRIC and WPG is generally sheared, the WPG is believed to unconformably overlie tonalitic rocks of the CRIC, based on the presence of clasts of CRIC in WPG conglomerates. This is consistent with their age difference.

All lithologies are cut by the late-tectonic, Strawberry (384 ± 2 Ma) and Isle aux Morts (386 ± 3 Ma) granites, composed of coarse-grained to porphyritic red granite (Dubé et al., 1996).

STRUCTURAL GEOLOGY

Six generations of structures have been documented within the Cape Ray Fault Zone (Dubé and Lauzière, in press A). The first two generations (D_1 and D_2), correspond to the amphibolite grade deformation and are restricted to the gneissic terranes of the PABG. D_3 to D_6 structures were developed during greenschist-grade metamorphism and are recorded in both the PABG and the WPG rocks.

The main fabric recognized in rocks of the PABG is a composite S_{1-2} gneissic layering. Peak metamorphic conditions were reached during the D_2 event (Burgess et al., 1993). An amphibolite-grade mylonite zone in GBC rocks is exposed along the coast near the WPG/GBC contact. It is characterized by a strong NE-oriented fabric (S_2) and contains moderate to steep S-plunging mineral lineations (L_2). Kinematic indicators point to reverse sinistral movement that occurred prior to 406 ± 4 Ma and 403 ± 4 Ma, which are the $^{40}Ar/^{39}Ar$ cooling ages for syn-kinematic hornblende and biotite (Dubé et al., 1996).

D_3 structures within the Cape Ray Fault zone affect WPG and GBC rocks and to a lesser extent CRIC intrusives. The D_3 increment of deformation occurred under greenschist conditions resulting in prograde metamorphism in the WPG rocks and retrogression and overprinting of the amphibolite-grade mylonites and gneisses of GBC. Two sets of structures are grouped under D_3. They are believed to be related to a single progressive deformational event because of their similarity in deformation style, metamorphic conditions and orientation of structures (Dubé and Lauzière, in press A). Structures are termed S_{3a}, S_{3b}, L_{3a}, L_{3b}, F_{3a}, F_{3b}. Where only one set is observed, structures are identified as S_{3a}, L_{3a} and F_{3a}.

Moderate-strain characterizes most of the WPG, although there is a general NWestward decrease in D_3 deformation away from the WPG/GBC contact. The bedding and a transposed S_{3a} foliation, are folded by S_{3b}. In most of the area, S_{3b} is a penetrative fabric, axial-planar to asymmetric F_{3b} folds. Commonly, S_{3a} is transposed into the S_{3b} fabric, producing a composite S_{3a-b} foliation. S_3 folding is also present in PABG, where it produces complex interference patterns defined by the gneissosity. S_{3a} and S_{3b} commonly strike NE to NNE and dip moderately SE to steeply NW. L_{3b} lineations plunge moderately E to ESE, although S-plunging stretching lineations were locally observed. Generally, F_3 hinges are sub-parallel to the stretching lineation and plunge steeply to moderately ESE.

Increasing deformation during D_3 generated narrow to wide zones of high strain. They are well developed at the CRIC/WPG contact but more intense at the WPG/PABG contact, where the zone varies in orientation from NE-SW to ENE in the flexure area of the fault zone.

The D_3 mylonite zone is made up of quartzo-feldspathic mylonites and schists produced either by extensive retrogression of the PABG, by shearing of the WPG rocks, or by shearing of the Rose Blanche Granite in the flexure area. Within the mylonites, the dominant fabric is an S-tectonite characterized by a mylonitic fabric (S_{3b}) which is probably a composite S_{3a-b} foliation and/or a compositional layering sub-parallel to the shear zone. In the NE-oriented segment of the fault, the mylonitic fabric contains a steeply to moderately E-plunging stretching lineation (L_3) and reverse-dextral kinematic indicators (Dubé and Lauzière, in press A). In the E-W oriented segment of the fault, the S_3 fabric contains a moderate SW-plunging to sub-horizontal stretching lineation, and dextral strike-slip to oblique slip motion is indicated by a number of kinematic indicators. This segment of the fault is interpreted as a tear fault accommodating differential shortening rates on either side (Dubé et al., 1996).

The upper time limit of the reverse shearing event is constrained by the intrusion of the early Devonian Isle aux Morts Granite (384 ± 2 Ma) that cuts across the reverse-oblique shear (Dubé et al., 1996).

Another greenschist-grade mylonite zone (D_4) is developed at/or near the WPG/CRIC boundary in the Isle aux Morts River area (Dubé and Lauzière, in press A). It can be traced for up to a few tens of metres NE of the Isle aux Morts River where it is in part cut by the Strawberry Granite. This mylonite gradually thins west of Big Pond, and persists as a high strain zone a few metres wide for up to 3 km west of Dog Pond. It is characterized by a steeply dipping ENE foliation (S_4) and compositional layering, and shallowly-plunging to sub-horizontal stretching lineations (L_4). Kinematic indicators suggest both dextral and sinistral apparent motions.

Two sets of late axial-planar cleavages (S_5, S_5') and associated local folds and kinks (F_5, F_5'), are developed at moderate to high angles to the main S_3 fabric along the Cape Ray Fault Zone. These structures are developed in all the structural domains and are post-mylonitic.

Late brittle faulting, D_6, is indicated by the presence of tectonic and hydrothermal breccias (Wilton, 1983) along the mylonite zone in the Isle aux Morts River area, and cuts the Strawberry Granite, indicating that it is post Mid-Devonian.

ECONOMIC GEOLOGY

The Cape Ray Fault Zone hosts the Cape Ray gold deposit, one of the most important vein-type gold deposits in the Appalachians, with proven mineable reserves of 450,000 tonnes at 10.1 gr/t Au (Dubé and Lauzière, in press B). Other significant vein-type gold mineralizations have been identified at Big Pond, Isle aux Morts and Windowglass Hill. At the Cape Ray gold deposit and Big Pond showing, gold mineralization occurs mainly in galena- and chalcopyrite-rich fault-fill quartz breccia-veins hosted by graphite schists of the WPG. The veins are located at or near the tectonic boundary between the WPG and the GBC. Other significant mineralized zones occur as extensional sub-horizontal quartz veins hosted by the Windowglass Hill Granite and as fault-fill quartz veins and strongly pyritized iron-rich sediments (Isle aux Morts Prospect) at or close to the contact between the CRIC and the WPG. The veins are base metal-rich and are characterized by low gold/silver ratios. The mineralization is post-424 Ma, the age of the Windowglass Hill Granite that is cut by mineralized veins, and must postdate the peak of metamorphism (415 Ma), because the gneisses are retrograded to greenschist facies within the Cape Ray gold deposit (Dubé and Lauzière, in press B). The mineralization is also pre-386 Ma, the age of the Isle aux Morts Granite which cuts the structures hosting the mineralization at the Cape Ray gold deposit. This time period corresponds to the development of D_3 structures.

The overprinting of thrust-related mylonites by low temperature hydrothermal breccia of epithermal style suggests a progression towards more extensional and brittle deformation with time and telescoping of near surface alteration style. Cross-cutting relationships suggest that the hydrothermal breccia is post -384Ma, the age of the brecciated Strawberry Granite. These late structures record declining temperature and pressure, possibly due to tectonic unloading.

ACKNOWLEDGEMENTS

The authors express their sincere thanks to Drs C. Van Staal, F. Robert, H.K. Poulsen, and G. R. Dunning for thoughtful, stimulating comments and observations in the field and to Dr. S.H. Swinden for his help in designing the project, and for sharing his metallogenic and geological experience of the Appalachian orogen. Drs M. Brown, Jayanta Guha, J. Winchester, M. Piasecki, and K. Currie are also thanked for discussions in the field. Very special thanks are also due to J. Thompson, J. Dawson, M. Dawson and L. McNeil of the mining industry for their collaboration, and for providing accommodation, logistical support and access to drill core, and underground exposures, as well as confidential information. M. Bélanger, P. Carpentier, G. Gosselin, D. Patry, C. Pelchat, S. Pitre and D. Watanabe provided excellent field assistance. David Graham and Gord Watson are thanked for providing satellite images and for their collaboration. The geology of the Isle aux Morts showing area is published with the authorization of Placer Dome.

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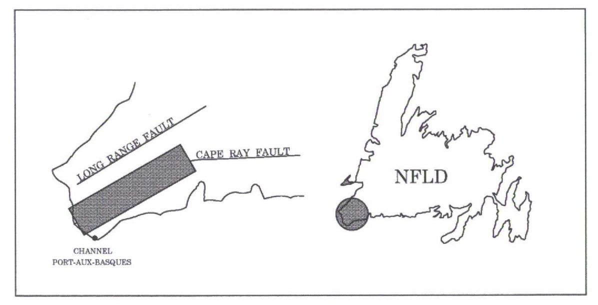

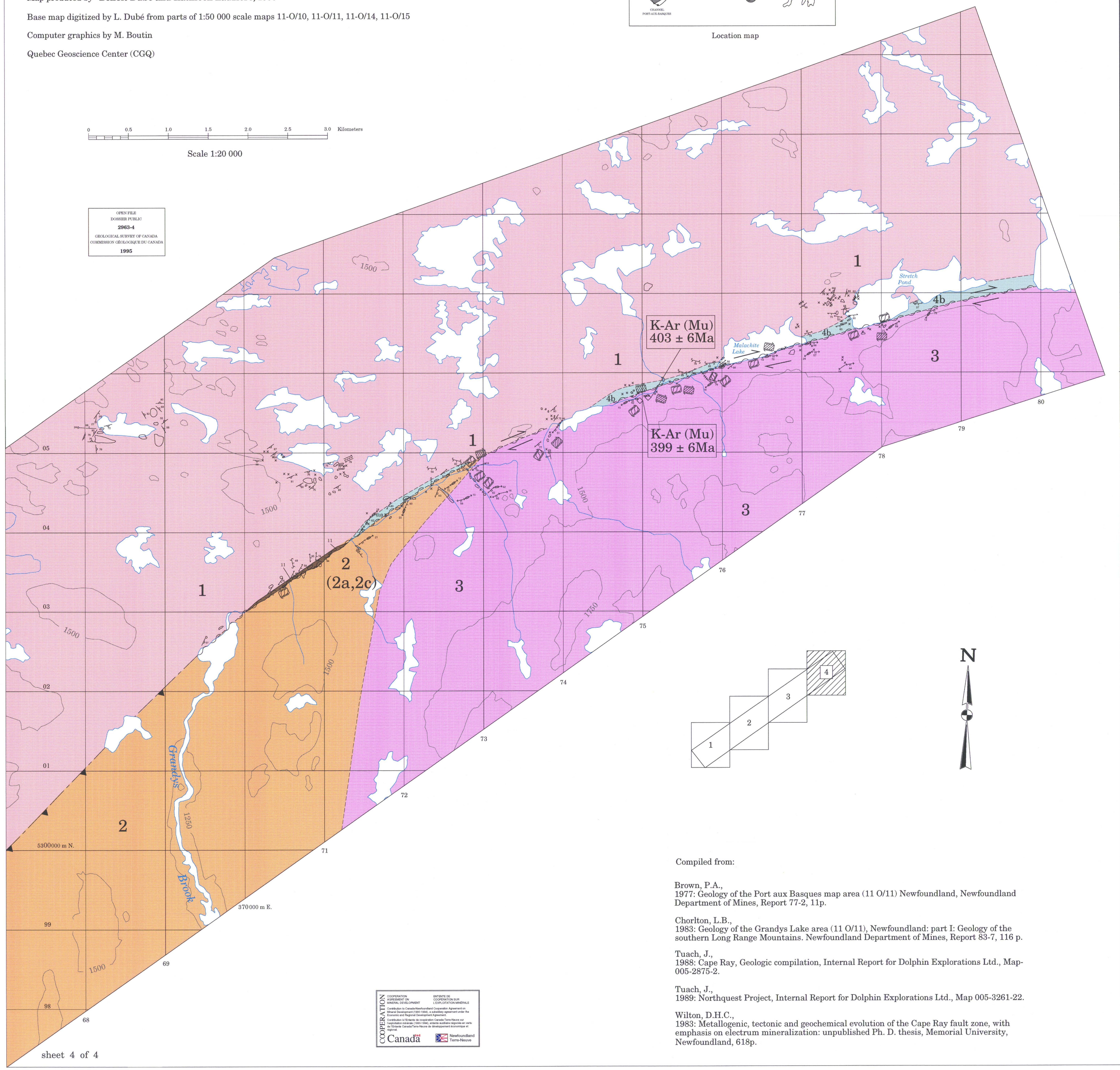

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LEGEND

Post-Early to Mid Devonian

- 11 Hydrothermal breccia, and cataclastic rocks.
- 10 Strike-slip mylonite (in Strawberry Granite)

Early to Mid Devonian

- Devonian granites
- 9 Isle aux Morts Granite — medium- to coarse-grained, equigranular to alkali feldspar-porphyritic, white to red biotite granite to granodiorite
- 8 Strawberry Granite

Late-Silurian to Early Devonian

- 7 Strike-slip mylonite (in the WPG, and/or in CRIC)
- 6 Mylonite (in the WPG)

Early Silurian

- 5 Windowglass Hill Granite (WGH)

Ordovician and Silurian

4 Windsor Point Group: Bimodal volcanic and volcaniclastic rocks with associated sedimentary rocks (WPG)

4b Windsor Point Group (Silurian)

- 4b1 Quartz-feldspar porphyry, felsic volcaniclastics
- 4b2 Mafic volcaniclastics
- 4b3 Conglomerate, polygenic to monogenic
- 4b4 Greywacke, shale and pebbly sandstone
- 4b5 Black shale and/or graphitic shale
- 4b6 Limestone
- 4b7 Gabbro
- 4b8 Chlorite-sericite schist and chlorite schist
- 4b9 Quartz-sericite schist

4a Ordovician to Silurian (Little Barachois Formation)

- 4a1 Rhyolite and associated pyroclastic and epiclastic rocks, locally quartz-feldspar-phyric
- 4a2 Polygenic conglomerate with abundant felsic volcanic clasts, typically magnetic
- 4a3 Graywacke and siltstone
- 4a4 Black shale and graphitic shale
- 4a5 Mafic volcanic, mostly massive, locally pillowed and brecciated with magnetic jasper fragments
- 4a6 Limestone
- 4a7 Sericite and/or chlorite schist

Silurian and older

3 Rose Blanche phase (Silurian)
Schistose to gneissic granitoid including tonalite, granodiorite and minor granite containing biotite and subordinate muscovite. Locally pegmatitic. Containing many country rock screens.

2 Port aux Basques Gneiss (Ordovician and older): 2I Grand Bay Complex (GBC), 2II Port aux Basques Complex (PBC)
Mainly semi-pelitic and pelitic schists, psammite and quartzo-feldspathic gneiss and mylonite, with minor amphibolite and pegmatitic intrusions

- 2a Semi-pelitic schist, mostly biotite-muscovite schist, locally gneissic, minor amphibolite and pegmatitic intrusions
- 2b Politic to semi-pelitic schist, psammite and phyllonite
- 2c Granitic gneiss
- 2d Quartzo-feldspathic gneiss, commonly mylonitic, includes muscovite-sericite schist
- 2e Amphibolite and retrograde chlorite schist
- 2f Chlorite and chlorite-sericite schist

Ordovician

1 Cape Ray Igneous Complex (CRIC)
Tonalite and other granitoid rocks with gabbroic enclaves

SYMBOLS

- Geological boundary a) defined, b) interpreted
- High-strain contact
- High-angle thrust fault
- Interpreted thrust fault
- Transitional boundary
- Strike-slip fault
- Fault
- outcrop visited
- trench
- mineral showing
- carbonate alteration zone
- geochronological sampling, sample location, age and geochronological method used (Ar-Ar (Hb) 406 ± 4Ma)
- bedding (WPG)
- S_{1-2} fabric (GBC)
- S_{3a} fabric a) WPG b) CRIC
- S_{3b} fabric a) GBC, b) WPG
- mylonitic foliation (S_4)
- crenulation cleavage (S_5-S_5')
- stretching lineation, measured on foliation surface
- mineral lineation, measured on foliation surface
- intersection lineation, measured on foliation surface
- crenulation lineation, measured on foliation surface
- shear with displacement a) unknown b) dextral, c) sinistral, d) reverse, e) normal
- fault with displacement a) unknown b) dextral, c) sinistral.
- striations on fault surface
- minor fold with axial plane a) S-shaped b) Z-shaped and c) M shaped
- minor fold with axial plane and fold axis a) S-shaped b) Z-shaped and c) M-shaped
- axial plane surface a) without and b) with fold axis
- kink bands a) dextral b) sinistral c) and plunge
- Vein
- SC mylonitic fabric a) dextral, b) sinistral, c) reverse
- shearbands a) dextral, b) sinistral, c) reverse

Abbreviations:

And	andalusite
ank	ankerite
Bt	biotite
Ct	calcite
Cp	chalcopyrite
Chl	chlorite
Ep	epidote
Fl	fluorite
Gn	galena
Gr	garnet
Gp	graphite
Au	gold
Hem	hematite
Hb	hornblende
ja	jasper
ICb	Iron carbonate
Mag	magnetite
Mu	muscovite
Py	pyrite

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