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Mines

**LITHOGEOCHEMICAL DATABASE FOR
IGNEOUS ROCKS FROM THE NORTHWESTERN
AVALON ZONE (NTS MAP AREAS 2C/05, 12, 13,
2D/01, 08, 09 AND 1N/12), NEWFOUNDLAND**

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Open File NFLD/3385

**St. John's, Newfoundland
September, 2020**

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SUMMARY

This database consists of litho-geochemical data from 51 samples of igneous rocks collected mainly from the Eastport–St. Brendan’s area, northwestern Avalon Zone, as well as seven from the Isthmus of Avalon, Newfoundland (Figure 1, NTS map areas 2C/05, 12, 13, 2D/1, 08, 09 and 1N/12). The regional geology is documented by O’Brien (1986, 1992; and O’Brien *et al.*, 1987) and the geology is summarized by O’Brien (1987, 1993; O’Brien and Knight, 1988; *see also* Younce, 1970). The rock samples were collected by A.J. Mills (2015–2017) and H.A.I. Sandeman (2009, 2010, 2012, 2015). Details of the analytical methods used are summarized below and further details are outlined by Finch *et al.* (2018).

The database includes brief sample descriptions, location data, field photographs, petrographic descriptions and photomicrographs, as well as major-element and trace-element data for 58 samples of mainly volcanic rocks. The data are available in digital format (*i.e.*, comma separated value files; *.csv). The open file data release provides no interpretation of the data. Results and interpretation of the litho-geochemistry of these rocks will be published at a later date (A.J. Mills, unpublished data, 2020).

NOTES ON DATABASE

All location data are presented in Universal Transverse Mercator (UTM), eastings and northings (Zone 22, NAD27) format. These were collected using a Trimble™ Juno 3B handheld unit (A. Mills) or a Garmin™ GPS unit (H. Sandeman). Samples are prefixed by the year and initials

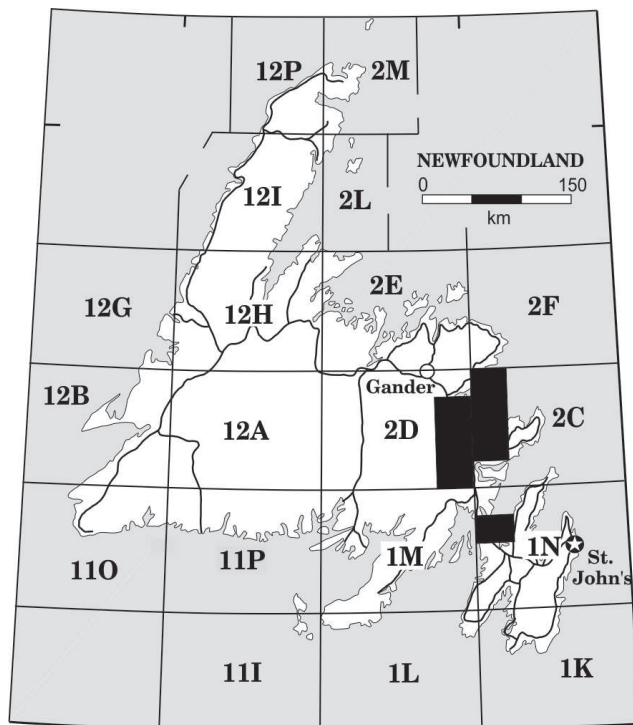


Figure 1. Location map of the study areas.

of the geologist who collected them. Samples prefixed ‘12AM’ were collected from the Isthmus of Avalon in 2016 in support of a B.Sc. (Hons.) thesis (Murphy, 2017). Appendix A contains litho-geochemical analytical data. Laboratory duplicate analyses are in Appendices B and C. In Appendix C, note that Lab Number 8940416 is a Field Duplicate of Lab Number 8940415. A number of reference materials (standards) were analyzed for quality control (Appendices D through N). Most data were analyzed at the Geological Survey’s Geochemical Laboratory (GSNL). Six samples were analyzed by Neutron Activation Analysis (INAA) at Becquerel Laboratories (Bec; now Bureau Veritas Laboratories, <https://www.bvlabs.com>) in Mississauga, ON, and these are indicated by ‘INAA’ as the Analysis Method in Appendix 1 (*see below for details*).

Major elements are presented as weight percentages of their oxides. The minor-, trace- and rare-earth elemental compositions are given in ppm, except for Au, Fe and Na (analyzed by Neutron Activation Analysis, INAA); these are presented as ppb for Au, and percent (pct) for Fe and Na. Volatiles are represented as loss-on-ignition (LOI) determined by gravimetric analysis.

Major elements and some trace elements (Ba, Be, Cr, Sc and Zr) were analyzed by inductively coupled plasma-optical emission spectrometry (ICP-OES-FUS) following lithium borate fusion and multi-acid attack. Other trace elements, including rare-earth elements (REE), were analyzed by inductively coupled plasma-mass spectrometry (ICP-MS-FUS) following lithium borate fusion and multi-acid attack. A subset of trace elements (As, Cd, Co, Cu, Li, Ni, Pb, Rb, V, Zn for AM samples; As, Ba, Be, Cd, Ce, Co, Cr, Cu, Dy, Fe, La, Li, Mn, Mo, Nb, Ni, P, Pb, Rb, Sc, Sr, Ti, V, Y and Zn for HS samples) were analyzed by ICP-OES with a four acid digestion (ICP-OES-4Acid). Silver was analyzed by ICP-OES following a nitric acid digestion (ICP-OES_HNO₃). Fluoride (F-) was analyzed by ion selective electrode (ISE) following a sodium carbonate and potassium nitrate fusion. Further details of analytical procedures are outlined by Finch *et al.* (2018).

Six of the rock samples were also analyzed by instrumental neutron activation analysis (INAA) at Becquerel Laboratories (Bec; now Bureau Veritas Laboratories, <https://www.bvlabs.com>) in Mississauga, ON. The INAA data are captured in separate columns (INAA). Basic analytical methods involve bombardment of the samples with neutrons in a nuclear reactor; followed by a radioactivity cooling interval and then the contained elements are identified and quantified by gamma ray spectral analysis (<https://www.bvlabs.com/markets-services/radiochemistry/radioactivity-testing>).

Calculations and abbreviations used in the database are described herein for clarity. The field 'Orig_Unit' is the original map unit, taken from regional bedrock maps (O'Brien, 1986, 1992; O'Brien *et al.*, 1987). Age constraints were determined by U–Pb dating of zircon by thermal ion mass spectrometry (TIMS: O'Brien and Dunning, unpublished data; O'Brien *et al.*, 1989), and by chemical abrasion (CA)-TIMS (Mills *et al.*, 2017). The 'Rev_Unit' is the revised map unit, based on geochronology and petrochemical interpretations, and expressed using abbreviations depicted in Table 1. Petrochemical interpretations and implications for stratigraphic nomenclature and the tectonic evolution of the Eastport area will be discussed in detail in a later publication (A.J. Mills, unpublished data, 2020). The symbol '-99' denotes the null value for an element that was not analyzed by the method specified. The Magnesium Number is defined as:

$$\text{Mg\#} = (\text{MgO}/40.312)/((\text{MgO}/40.312)+(\text{FeO}^{\text{T}}/71.847))*100.$$

Within the Duplicates Table (Appendices B and C):

$$\%_{\text{difference}} = |[(\text{Original Value} - \text{Lab Duplicate Value})/\text{Mean Value}]| * 100.$$

In the %_difference rows, BD = Below Detection, and is used where both the original sample value and duplicate value are less than the limit of detection; LOD = Limit of Detection, where either the original sample value or the duplicate value (but not both) is less than the limit of detection.

Table 1. Key to ‘Revised_Map_Unit’ (Column J, Appendix A)

LHIS	Louil Hills Intrusive Suite
RH_wir	Rocky Harbour Formation, upper Musgravetown Group (MG), Wolf Island rhyolite
RH_brr	Rocky Harbour Formation, upper MG, Bloody Reach rhyolite
RH_brb	Rocky Harbour Formation, upper MG, Bloody Reach basalt
LC_s	Love Cove schist (possibly correlative to Bull Arm Formation, MG)
RH_iab	Rocky Harbour Formation, MG (basalt 1, Isthmus of Avalon area)
BA_iab	Bull Arm Formation, MG (basalt 2, Isthmus of Avalon area)
BA_b1	Bull Arm Formation, MG (tholeiitic basalt 1; Eastport area)
BA_b2	Bull Arm Formation, MG (tholeiitic basalt 2; Eastport area)
BA_dhr	Bull Arm Formation, MG (Doe Hills rhyolite, Isthmus of Avalon area)
CC_b	Cannings Cove Formation, MG (calc-alkaline basalt)
BIG	Broad Island Group (formerly Love Cove Group)

Reference Materials Tables (Appendices D through N):

Analytical elemental values for reference materials were compared to accepted values (*see* Finch *et al.*, 2018) and the majority of analytical values fall within the range for accepted values. Analytical values for a few elements fall outside the accepted ranges, but only by a small margin and only for those elements having accepted values that are close to detection limits. This quality assurance adds confidence to the accuracy of the dataset.

Field photographs and photomicrographs are available in digital zip compressed files in Appendices O and P, respectively.

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Chris Finch and the staff at the Geological Survey of Newfoundland and Labrador, Howley Building Geochemical Laboratories, are acknowledged for their excellent work in obtaining the high-quality lithochemical data. Field assistance (to A. Mills) was provided by J. David Haynes. Mr. Everett Saunders of Eastport provided excellent guidance as boatman. Monica Squires is thanked for support in compiling the data. Pauline Honarvar provided excellent guidance in formatting of the database and, along with Steve Amor, conducted a thorough review of the data for quality assurance. Terry Sears generated the index map.

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APPENDICES A–P

Appendices A–N are available as digital comma-separated files (.csv) and Appendices O and P are available as digital images (.jpg) in zip files through [this link](#).

- Appendix A:** Major-element and Trace-element GSNL Data for Rocks from Northwestern Avalon Terrane
- Appendix B:** Major-element and Trace-element for GSNL Duplicates (AM samples)
- Appendix C:** Major-element and Trace-element for GSNL Duplicates (HS samples)
- Appendix D:** Major-element ICP-OES Data (for reference materials that were analyzed along with samples from Northwestern Avalon Terrane – AM samples)
- Appendix E:** Trace-element ICP-MS Data (for reference materials that were analyzed along with samples from Northwestern Avalon Terrane – AM samples)
- Appendix F:** Trace-element ICP-OES Data (for reference materials that were analyzed along with samples from Northwestern Avalon Terrane – AM samples)
- Appendix G:** Silver (Ag) Data Obtained through ICP-OES and Nitric Acid Digestion (for reference materials that were analyzed along with samples from Northwestern Avalon Terrane – AM samples)
- Appendix H:** Fluoride (F-) Ion Specific Electrode (ISE) Data (for reference materials that were analyzed along with samples from Northwestern Avalon Terrane – AM samples)
- Appendix I:** Major-element ICP-OES Data (for reference materials that were analyzed along with samples from Northwestern Avalon Terrane – HS samples)
- Appendix J:** Trace-element ICP-MS Data (for reference materials that were analyzed along with samples from Northwestern Avalon Terrane – HS samples)
- Appendix K:** Trace-element ICP-OES Data (for reference materials that were analyzed along with samples from Northwestern Avalon Terrane – HS samples)
- Appendix L:** Trace-element INAA Data (for reference materials that were analyzed along with samples from Northwestern Avalon Terrane – HS samples)
- Appendix M:** Silver (Ag) Data Obtained through ICP-OES and Nitric Acid Digestion (for reference materials that were analyzed along with samples from Northwestern Avalon Terrane – HS samples)
- Appendix N:** Fluoride (F-) Ion Specific Electrode (ISE) Data (for reference materials that were analyzed along with samples from Northwestern Avalon Terrane – HS samples)
- Appendix O:** Field Photographs. (The .jpg file names correspond to the names in the Field_Photo column in the GSNL Data spreadsheet in Appendix A.)
- Appendix P:** Photomicrographs. (The .jpg file names correspond to the names in the TS_Photo column in the GSNL Data spreadsheet in Appendix A.)