



Industry, Energy and Technology

Mines

**DATA COMPILATION FOR MAFIC DYKES
FROM THE AVALON ZONE, NEWFOUNDLAND
(NTS MAP AREAS 2C/03, 04, 05, 06, 11, 12, 13,
2D/01, 08, 1N/05, 06, 12 AND 13)**

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SUMMARY

This data release is intended to be the first iteration of an Avalonian dyke database that may be superseded as additional data is obtained. This data is a compilation of the key attributes of dykes (and sills) of the Avalon Zone, including: lithology of the dyke/sill and the rock that it intrudes (*i.e.*, country rock), the stratigraphic unit (*see* King, 1988; Jenness, 1963) to which the country rock is designated, location data, trend, dip, thickness, and colour. It is currently focused on those areas in which the first author has conducted field work, with data compiled from previous workers. Hence, lithochemical analyses are not available for every record in the compilation. Likewise, field photographs and petrographic descriptions are available only for select records. The authors anticipate that the database may serve as a useful resource for geoscientists exploring various aspects of Avalonian evolution.

No interpretation is applied to this data compilation, however, a preliminary interpretation of a small subset of the data was offered by Mills and Sandeman (2017). Papezik and Hodych (1980) provided details on the petrochemistry, mineralogy, age and origin of early Mesozoic diabase dykes of the Avalon Peninsula. Skipton *et al.* (2013) provide interpretation of chemical, isotopic and age constraints on a late Ediacaran intrusive complex on the northeast Avalon Peninsula. Interpretations of the magmatic evolution of the Avalon Zone in Newfoundland, based on local studies, are also available (*e.g.*, Papezik, 1970; Strong *et al.*, 1978; Dunning and O'Brien, 1989; Mills and Sandeman, 2015, 2021a, b; Mills *et al.*, 2021), and van Staal *et al.* (2021) provide a summary of the tectonomagmatic evolution of West Avalonia.

NOTES ON THE DATABASE

For ease of plotting, location data is reported in both latitude/longitude, as well as NAD27, Zones 21 and 22 UTM coordinates. Stations from which the data were collected are typically pre-

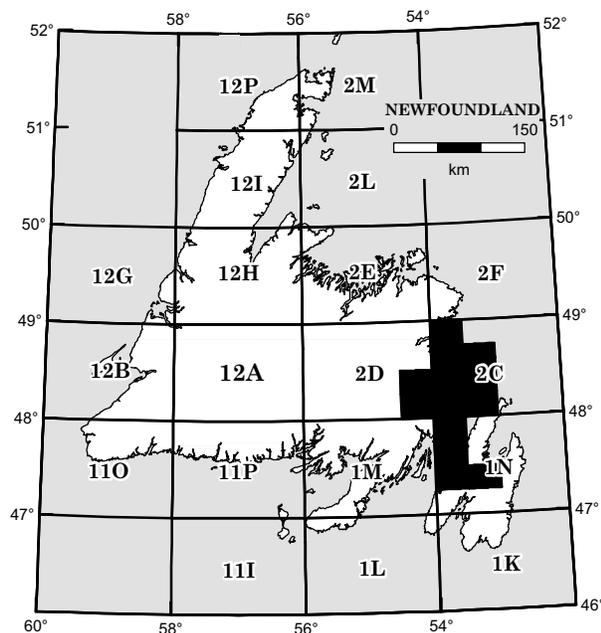


Figure 1. Location map of study area.

fixed by the year and initials of the geologist who collected them. Appendix A contains brief lithological descriptions, location data, stratigraphic unit of the country rock, as well as the trend, dip and thickness (metres) of the dykes. In cases where the thickness is less than the specified value, a minus (-) sign is assigned; all positive values indicate a minimum thickness. Where available, major- and trace-element, whole-rock geochemical analytical data are also provided. Mineral abbreviations used within the appendices follow Whitney and Evans (2010); other abbreviations are defined in Table 1.

Analytical duplicates (Appendix B), selected at random and inserted at a frequency of one in 20, and a number of reference materials (Standards) were analyzed (Appendix C)

Table 1. List of abbreviations

Abbreviation	Explanation
-99	Samples not analyzed for that element
Avg	Average value
Dup	Duplicate analysis
Fe ₂ O ₃ T	Total measured iron
FeOT	Total iron (II), calculated from total measured iron (III)
ICP-OES-4-ACID	Inductively Coupled Plasma-Optical Emission Spectrometry following HF-HCl-HNO ₃ -HClO ₄ acid digestion
ICP-OES-FUS	Inductively Coupled Plasma-Optical Emission Spectrometry following lithium metaborate/tetraborate fusion
ICP-OES-HNO ₃	Inductively Coupled Plasma-Optical Emission Spectrometry following nitric acid digestion
ICP-MS-FUS	Inductively Coupled Plasma-Mass Spectrometry following lithium metaborate/tetraborate fusion
INAA	Instrumental Neutron Activation Analysis
ISE	Ion-selective electrode
LCL	Lower control limit
LOI	Loss-on-ignition
negative number	Below detection limit
pct	Percent
ppm	Parts per million
Rec_Val	Recommended value
UCL	Upper control limit
wt_pct	Weight percent

as part of the Geological Survey of Newfoundland and Labrador's internal quality control measures. Details of the analytical methods used are provided by Finch *et al.* (2018) and summarized in Table 2. The data are available in digital format (*i.e.*, comma separated value files; *.csv). Field photographs are provided for 41 dykes (Appendix D).

Major-element compositions (plus Ba, Be, Cr, Sc and Zr) were analyzed by ICP-OES methods, following lithium tetraborate and metaborate fusion. REE and selected trace elements were determined by ICP-MS analysis following lithium tetraborate and metaborate fusion, whereas other trace elements (As, Ba, Be, Cd, Ce, Co, Cr, Cu, Dy, Fe, La, Li, Mn, Mo, Nb, Ni, P, Pb, Rb, S, Sc, Sr, Ti, V, Y and Zn) were analyzed by ICP-OES after total 4-acid digestion. These analytical procedures are described in Finch *et al.* (2018). Trace elements were also analyzed with INAA by the external commercial laboratory Bureau Veritas (formerly Becquerel/Maxxam).

Volatiles are represented as loss-on-ignition (LOI) at 1000°C, which represents the breakdown of all minerals and release of all volatiles. The ferrous-iron content (FeO) of silicate rocks is determined by the Wilson Method (Wilson, 1960). For silver analysis, 0.5 g of sample powder was

Table 2. Analytical methods for the geochemical analyses

Element	Analytical Method	Preparation/Digestion
SiO ₂ , Al ₂ O ₃ , Fe ₂ O ₃ T, MgO, CaO Na ₂ O, K ₂ O, TiO ₂ , MnO, P ₂ O ₅ , Ba, Be, Cr, Sc, Zr	ICP-OES	50-50 Lithium Tetraborate Lithium Metaborate Fusion
Fe ₂ O ₃ , FeOT	Calculation	
FeO	Titration	NH ₄ VO ₃ , HF, H ₂ SO ₄ , H ₃ PO ₄
As, Ba, Be, Cd, Ce, Co, Cr, Cu, Dy, Fe, La, Li, Mn, Mo, Nb, Ni, P, Pb, Rb, S, Sc, Sr, Ti, V, Y, Zn	ICP-OES	HF-HCl-HNO ₃ -HClO ₄ (total digestion)
As, Bi, Cd, Ce, Co, Cs, Dy, Er, Eu, Ga, Gd, Ge, Hf, Ho, In, La, Lu, Mo, Nb, Nd, Pr, Sm, Sn, Sr, Ta, Tb, Th, Tl, Tm U, V, W, Y, Yb, Zr	ICP-MS	50-50 Lithium Tetraborate Lithium Metaborate Fusion
F	ISE	Na ₂ CO ₃ and KNO ₃ fusion
Ag	ICP-OES	HNO ₃ digestion
LOI	Gravimetric (Grav) at 1000°C	None
As, Au, Ba, Br, Ce, Co, Cr, Cs, Eu, Fe, Hf, La, Lu, Mo, Na, Rb, Sb, Sc, Se, Sm, Ta, Tb, Th, U, W, Yb, Zr	INAA	

weighed into a 15 ml digestion tube with 2 ml of concentrated nitric acid, and digested for two hours and then analyzed by ICP-OES (Finch *et al.*, 2018). Fluoride content is determined as described by Ficklin (1970).

Major elements are reported in weight percent (wt. %), and minor and trace elements are reported in parts per million (ppm). A negative number indicates that the element concentration was below the detection limit (*e.g.*, -0.01 indicates the measured value was below the detection limit of 0.01). Detection limits are listed for each element in the .csv files. The code -99 indicates the sample was not analyzed for that element.

Mg# was determined by the formula:

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

Within the Duplicates Table (Appendix B):

$$\%_difference = [(OriginalValue - Lab Split Value)/Original Value] * 100$$

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Chris Finch and the staff at the Geological Survey of Newfoundland and Labrador geochemical laboratory continually provide high-quality lithochemical data in a timely fashion. We thank Hamish Sandeman for the data he contributed. Thanks also go to Megan Reardon for thorough review of the data for quality assurance.

REFERENCES

Dunning, G.R. and O'Brien, S.J.

1989: Late Proterozoic–early Paleozoic crust in the Hermitage flexure, Newfoundland Appalachians: U/Pb ages and tectonic significance. *Geology*, Volume 17, pages 548-551.

Ficklin, H.E.

1970: A rapid method for the determination of fluorine in rocks and soils, using an ion selective electrode. U.S. Geological Survey, Paper 700C, pages 186-188.

Finch, C., Roldan, R., Walsh, L., Kelly, J. and Amor, S.D.

2018: Analytical methods for chemical analysis of geological materials. Government of Newfoundland and Labrador, Department of Natural Resources, Geological Survey, Open File NFLD/3316, 67 pages.

Hayes, A.O.

1948: Geology of the area between Bonavista and Trinity bays, eastern Newfoundland. Geological Survey of Newfoundland, Bulletin 32 (Part 1), pages 1-37.

Jenness, S.E.

1963: Terra Nova and Bonavista map-areas, Newfoundland (2D E1/2 and 2C). Geological Survey of Canada, Memoir 327, 184 pages.

King, A.F.

1988: Geology of the Avalon Peninsula, Newfoundland (parts of 1K, 1L, 1M, 1N and 2C). Government of Newfoundland and Labrador, Department of Mines, Mineral Development Division, Map 88-01.

Mills, A.J., Dunning, G. and Sandeman, H.

2021: Age-constrained arc- to rift-magmatism in northwestern and central Avalon Terrane, Newfoundland, and implications for lithostratigraphy. *Canadian Journal of Earth Sciences*. <https://doi.org/10.1139/cjes-2019-0196>

Mills, A. and Sandeman, H.A.

2015: Preliminary lithogeochemistry for mafic volcanic rocks from the Bonavista Peninsula, northeastern Newfoundland. *In* Current Research. Government of Newfoundland and Labrador, Department of Natural Resources, Geological Survey, Report 15-1, pages 173-189.

2017: Lithogeochemistry of mafic intrusive rocks from the Bonavista Peninsula, Avalon Terrane, northeastern Newfoundland. *In* Current Research. Government of Newfoundland and Labrador, Department of Natural Resources, Geological Survey, Report 17-1, pages 19-39.

2021a: Reconnaissance lithogeochemical investigation of the Bull Arm Formation and significance of diamictite in the overlying Big Head Formation in the Long Harbour–Placentia area, western Avalon Peninsula, Newfoundland. *In* Current Research. Government of Newfoundland and Labrador, Department of Industry, Energy and Technology, Geological Survey, Report 21-1, pages 73-96.

2021b: Lithostratigraphy and lithogeochemistry of Ediacaran alkaline basaltic rocks of the Musgravetown Group, Bonavista Peninsula, northeastern Newfoundland, Canada: An extensional volcanogenic basin in the type-Avalon terrane. *Atlantic Geology*, Volume 57, pages 207-234. <https://doi.org/10.4138/atlgeol.2021.010>

Papezik, V.S.

1970: Petrochemistry of volcanic rocks of the Harbour Main Group, Avalon Peninsula, Newfoundland. *Canadian Journal of Earth Sciences*, Volume 7, pages 1485-1498.

Papezik, V.S. and Hodych, J.P.

1980: Early Mesozoic diabase dikes of the Avalon Peninsula, Newfoundland: Petrochemistry, mineralogy, and origin. *Canadian Journal of Earth Sciences*, Volume 17, pages 1417-1430.

Skipton, D.R., Dunning, G.R. and Sparkes, G.W.

2013: Late Neoproterozoic arc-related magmatism in the Horse Cove Complex, eastern Avalon Zone, Newfoundland. *Canadian Journal of Earth Sciences*, Volume 50, pages 462-482.

Strong, D.F., O'Brien, S.J., Taylor, S.W., Strong, P.G. and Wilton, D.H.

1978: Aborted Proterozoic rifting in eastern Newfoundland. *Canadian Journal of Earth Sciences*, Volume 15, pages 117-131.

van Staal, C.R., Barr, S.M., McCausland, P.J.A., Thompson, M.D. and White, C.E.

2020: Tonian–Ediacaran tectonomagmatic evolution of West Avalonia and its Ediacaran–early Cambrian interactions with Ganderia: an example of complex terrane transfer due to arc-arc collision? *In* Pannotia to Pangaea: Neoproterozoic and Paleozoic Orogenic Cycles in the Circum-Atlantic Region. *Edited by* J.B. Murphy, R.S. Strachan and C. Quesada. Geological Society of London, Special Publications 503, pages 143-167.

Whitney, D.L. and Evans, B.W.

2010: Abbreviations for names of rock-forming minerals. *American Mineralogist*, Volume 95, pages 185-187.

Wilson, A.D.

1960: The micro-determination of ferrous iron in silicate minerals by a volumetric and a colorimetric method. *Analyst*, Volume 85, Issue 1016, pages 823-827.

APPENDICES

Appendices A–C are included in the OF_NFLD_3445 zip folder as Comma Delimited Value (.csv) files and Appendix D consists of field photographs as jpgs.

APPENDIX A: Major-element and Trace-element Data

APPENDIX B: Major-element and Trace-element Data for Duplicates

APPENDIX C: Major-element and Trace-element Data for Standards, with Certified Reference Materials

APPENDIX D: Field photographs