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Miscellaneous Release—Data 315

Geochemistry of Neoarchean Volcanic and Intrusive Rocks in Aldina Township, Northwestern Ontario

by R.W.D. Lodge*

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This publication can be downloaded from
http://www.geologyontario.mndm.gov.on.ca/mndmaccess/mndm_dir.asp?type=pub&id=MRD315

This geographic information system (GIS)-based release comprises field photographs and geochemical data that were collected during the mapping of Aldina Township, northwestern Ontario, in 2010 and 2013 (Lodge 2014). The geospatially controlled field and geochemical data include

- observations and descriptions of lithofacies, alteration and mineralization;
- photographs of a variety of outcrops and rock textures from the field; and
- various plots (proportional dot plots, coloured-by-value plots) illustrating values of important petrogenetic trace-element ratios and concentrations of base metals in the rocks.

Presentation of the data for Aldina Township is provided as GIS project files (ESRI® ArcGIS® 10.1 project (*.mxd*) file and ESRI® ArcGIS® 9.3 geodatabase (*.gdb*) project files); also provided are the results of 65 geochemical analyses in Microsoft® Excel® format (*.xlxs*), along with Geoscience Laboratories' (Geo Labs) certificates of analysis as portable document format (*.pdf*) and comma separated values (*.csv*) files. Field observations with descriptions of lithofacies, alteration and mineralization, and the photograph descriptions are provided within the GIS project files. This release also includes 65 photographs (*.jpg* files of field, sample slabs, thin sections), images of various plots (*.lyr* format files, to be used in ESRI® ArcGIS®), and supporting documentation (*.pdf* file).

Folder Structure

The contents of MRD 315 are organized into folders based on data type. Folder names indicate the data type or location of data contained in the folder. The readme and metadata files are located in the root directory. The data can be transferred to the local computer's hard drive, but it is very important to retain the folder names and file structure. The map documents are dependent upon the current file structure. The entire project folder can reside anywhere on the computer.

MRD 315 contains the following folders and files in the DATA folder:

- DATA
  - GEOCHEMISTRY
  - GEOCHEMISTRY_PLOTS
  - LEGEND_Map P.3776
  - LODGE_ALDINA_MRD.gdb
  - PHOTOS
  - ERGMSsymbology.zip*
  - Lodge_Aldina_MRD.mxd
- MRD315_Metadata.pdf
- MRD315_Readme.pdf

*This ZIP file contains the fonts used in all Ontario Geological Survey ERGMS GIS projects. Users must install the fonts within this zip file before opening the ArcGIS® MXD file, otherwise the symbology used in the map will not display correctly.

Field Photographs

The folder named "PHOTOS" contains subfolders that are labelled according to the station number. The images contained within the folder are hyperlinked to the PHOTOS layer and can be viewed directly from the ArcGIS® project.

GIS Map Files

GIS DATA LAYERS AND ATTRIBUTES

a) Map Projections, Scale and Base Map Information

Data for the Aldina Township are in the UTM Projection, Zone 16, using North American Datum 1983 (NAD83).

The digital base map layers for the data sets were derived from data downloaded from Land Information Ontario Data Warehouse, Land Information Ontario, Ontario Ministry of Natural Resources and Forestry with modifications by staff of the Ontario Geological Survey.

b) Description of the Map Document

The map document (*.mxd*) contains one data frame set at a reference scale of 1:20 000 and the display is shown in metres.

The geology contained within the data frame is based on OGS Map P.3776, *Precambrian Geology of Aldina Township* (Lodge 2014).

c) Hyperlinks

When you click a feature with the Hyperlink tool, a photo or image will be opened using your default photo viewing application. The following instructions are *modified from* ESRI® help files.

1. On the Tools toolbar, click the Hyperlink tool. This transforms your mouse pointer into a lightning bolt. Note: Any visible features in the map that have hyperlinks defined are drawn in blue, the default colour, or outlined in blue in the case of polygons. When you hover the pointer over a feature for which a hyperlink exists, the mouse pointer turns into a black lightning bolt with a flash, and you see a pop-up tip with the name of the target.
2. Click on feature PHOTOS in your data frame to access hyperlink information.
3. This will bring up a photo or image related to that point. If several hyperlinks are specified for a feature, ArcMap® will pop up a list of the hyperlinks when the feature is clicked with the Hyperlink tool.
4. If you have hyperlinks turned on for multiple layers, clicking a location in your data frame provides a Hyperlinks dialog box to choose a feature from one of the layers. The layer name is listed in parentheses.

d) Data Sets and Attributes

FEATURE DATA SET	FEATURE CLASS	FEATURE CLASS DECRIPTION	FIELDS	ATTRIBUTE DESCRIPTION
ANNOTATION				
	LEADERLINES	Annotation layers used to display the various labels for the geology, topographic and field data layers.		
	MDI_Anno			
	MINERALISATION_Anno			
	STATIONS_Anno			
	STRUCTURE_Anno			
	TOPO_Anno			
FIELDDATA				
	ALTERATION	Point alteration layer.		
	INTRUSIVE	Point intrusive layer.		
	LITHOLOGY_2010			
	MDI	Point layer representing mineral occurrences.	P_COMMOD	A list of the primary resources at the occurrence.

FEATURE DATA SET	FEATURE CLASS	FEATURE CLASS DECRIPTION	FIELDS	ATTRIBUTE DESCRIPTION
	METAMORPHIC	Point metamorphic layer.		
	MINERALISATION	Point 5ineralization layer.		
	NEATLINE	Polygon layer representing the map boundary.		
	OUTCROP	Polygon outcrop layer.	MAPCODE	Contains a generalized lithographic code used to define the geological unit for display.
	PHOTOS	Point photo layer.	LINK	Use the hyperlink tool to open and view the field photos.
	SEDIMENT			
	STATIONS	Point stations layer.	LITHOCODE	Contains the lithographic code used to define the geological unit.
	STRUCTURE	Point structure layer.	SYMBOL	Standard digital bedrock mapping symbols from OFR 5909 (Jackson, Muir and Romkey 1995).
	VOLFLOW	Point layer representing volcanic flow.		
	VOLPYRO	Point layer representing volcanic pyro?		
GEOCHEMISTRY				
	FELSIC	Felsic subset of geochemical analysis data.		
	GEOCHEMISTRY	Geochemical analysis data of all samples.		

FEATURE DATA SET	FEATURE CLASS	FEATURE CLASS DECRIPTION	FIELDS	ATTRIBUTE DESCRIPTION
GEOLOGY	MAFIC	Mafic subset of geochemical analysis data.		
	LITHOLOGY_LINES	Geology line feature class featuring contacts and faults.	LINECODE	Standard digital bedrock mapping line code, representing line type, from OFR 6026 (Muir, Watkins and Berdusco 2000).
	LITHOLOGY_POLYGONS	Geology polygon feature class.	MAPCODE	Contains a generalized lithographic code used to define the geological unit for display.
TOPODATA	LAKES RIVERS ROADS WETLAND	Digital base map layers for the data sets were derived from data downloaded from Land Information Ontario Data Warehouse, Land Information Ontario, Ontario Ministry of Natural Resources and Forestry with modifications by staff of the Ontario Geological Survey.		

GEOCHEMISTRY DOT PLOTS

The information contained within these layers displays various elements, ratios and calculated indices that are useful for determining the petrogenesis and VMS-associated properties of each region. Some of these ratios, in addition to primitive mantle–normalized trace element extended element (“spider”) diagrams, were used to create the magmatic and tectonic affinity polygons.

Plots for all Suites of Rocks

La/Sm – Measures slope of chondrite-normalized light REE pattern (Sun and McDonough 1989). Note that divisions are arbitrary and the overall observation of slope on these diagrams is qualitative based on the overall shape of the "spider" diagram.

- (smallest dot) <0.9 Depleted
- (small dot) 0.9 - 1.5 Flat
- (medium dot) 1.5 - 3 Slightly Enriched
- (large dot) >3 Strongly Enriched

Gd/Yb – Measures slope of chondrite-normalized Heavy REE pattern (Sun and McDonough 1989). Note that divisions are arbitrary and the overall observation of slope on these diagrams is qualitative based on the overall shape of the "spider" diagram.

- (large dot) <0.9 Enriched
- (small dot) 0.9 - 3 Depleted
- (smallest dot) > 3 Strongly Depleted

La/Yb – Measures overall slope of chondrite-normalized REE pattern (Sun and McDonough 1989). Note that divisions are arbitrary and the overall observation of slope on these diagrams is qualitative based on the overall shape of the "spider" diagram.

- (smallest dot) <0.9 REE depleted
- (small dot) 0.9 - 2 Flat
- (medium dot) 2 - 15 Gently dipping
- (large dot) >15 Steeply dipping

Zn – Measures base metal enrichment. In general, most nonmineralized and volcanic rocks have low abundances of base metals (<100 ppm).

- (smallest dot) <100 ppm
- (small dot) 100 - 500 ppm
- (medium dot) 500 - 1000 ppm
- (large dot) > 1000 ppm

Cu – Measures base metal enrichment. In general, most nonmineralized volcanic rocks have low abundances of base metals (<100 ppm).

- < 100 ppm
- 100 - 500 ppm
- 500 - 1000 ppm
- >1000 ppm

CCPI Index – Measures intensity of VMS-type alteration. Based on the principal that Fe and Mg are added as chlorite, pyrite and carbonate, and Na is lost by the destruction of feldspar (Large et al. 2001). Note that mafic samples are biased toward higher alteration signatures because of their lower Na and higher Fe and Mg contents prior to alteration.

- < 70 Weakly Altered
- 70-90 Moderate Alteration
- >90 Strongly Altered

Ishikawa Index – Measures intensity of VMS-type alteration. Based on the principle that Mg and K are added as chlorite and sericite while Ca and Na are lost via the destruction of feldspar (Ishikawa et al. 1976). Note that mafic and ultramafic samples are biased toward higher alteration signatures because of their lower Na and higher Mg contents prior to alteration.

- < 70 Weakly Altered
- 70-90 Moderate Alteration
- >90 Strongly Altered

Ce/Ce* – Measures mobility of rare earth elements based on the presence of a Ce anomaly on a chondrite-normalized REE diagram (Polat and Hoffman 2003). No Ce anomaly should exist if samples did not experience REE mobility, and the value of the index should be close to 1.

- <0.9 REE mobile
- 0.9 - 1.1 REE not mobile
- > 1.1 REE mobile

Nb/Y – Measures alkaline versus sub-alkaline. Based on the Nb/Y versus Zr/Ti rock classification diagram from Pearce (1996).

- < 0.7 sub-alkaline
- > 0.7 alkaline

Na_2O – Measures Na depletion during VMS-alteration (Spitz and Darling 1978). This index is commonly used to quickly screen for alteration. However, samples that have low feldspar contents, such as mafic to ultramafic suites, will have low Na regardless of degree of alteration.

- < 2 wt % Na Depleted
- > 2 wt % Normal

LOI – Measuring hydration that is associated with hydrothermal alteration. This index is commonly used to quickly screen for alteration. However, there are many other mechanisms for hydration of a sample independent of VMS-type alteration.

- < 4.5 wt % Altered
- > 4.5 wt % Normal

Al_2O_3/Na_2O – Spitz–Darling Alteration Index. Measures depletion of Na via destruction of feldspars against conserved Al (Spitz and Darling 1978). Note that samples with low plagioclase content (mafic to ultramafic rocks) will have "altered" signatures regardless of hydrothermal alteration.

- < 10 Normal
- > 10 Altered

Ti/Sc – Measures petrogenetic source. Mantle-derived melts have lower Ti relative to Sc contents because of differences in compatibility during melting. Crustal-derived melts will have enriched Ti relative to Sc (e.g., Piercey et al. 2008). Basaltic rocks that show crustal signatures have experienced significant crustal contamination.

- < 150 Mantle
- 150 - 350 Mixed Signature
- > 350 Upper Crust

Plots Specifically for Basaltic Rocks Based on Pearce (1996)

Ti/V – Magmatic affinity for basalts based on Shervais (1982). Note that this classification is not appropriate for discriminating calc-alkalic mafic suites.

- < 10 Low Ti Island Arc Tholeiite/Boninite
- 10-20 Island Arc Tholeiite
- 20-50 MORB, BABB
- > 50 Alkaline

Nb/Th(pm) – Measures relative anomalies of Th and Nb on a primitive mantle (pm)–normalized trace element diagram. Arc basalts derived from a subduction-enriched mantle are enriched in Th relative to Nb (e.g., Polat 2009). Mid-ocean ridge basalts (MORB) are depleted in Th relative to Nb. Back-arc basalts are often a mixture of the 2 signatures. Note that the subdivisions were chosen to best approximate the different patterns on a trace element diagram.

- < 0.4 Arc-like
- 0.4 - 0.9 BABB-like
- 0.9 - 1.1 mature BABB-like
- > 1.1 MORB-like

La/Sm(ch) – Measures enrichment in LREE on a chondrite (ch)-normalized REE plot as an approximation for tectonic setting (e.g., Piercey 2007). Mid-ocean ridge basalts (MORB) basalts are depleted in LREE and will have negative slopes (La/Sm <0.9). Arc basalts will be strongly enriched in LREE. Note that the subdivisions were chosen to best approximate the different patterns. However, basalts can also be enriched by mantle plumes.

- < 0.9 MORB-like
- 0.9 - 2 BABB-like
- > 2 ARC-like

Plots Specifically for Felsic Rocks Based on Pearce (1996)

Zr/Y – Estimation of F-type felsic rock classification (Lesher et al. 1986). This discrimination is more often plotted on a Zr/Y versus Y discrimination diagram. However, the enrichment in Y is the critical component of this discrimination and influences the Zr/Y ratio.

- < 4 F-III Type
- 4 - 10 F-II Type
- > 10 F-I Type

La/Yb(ch) – Estimation of F-type felsic rock classification (Hart, Gibson and Lesher 2004). This discrimination is more often plotted on a La/Yb(ch) versus Yb(ch) discrimination diagram. The principle is that FIII-type felsic rocks have relatively flat chondrite-normalized REE patterns noted also by enriched HREE patterns.

- < 5 F-III
- 5 - 10 F-II
- > 10 F-I

Yb(ch) – Estimation of F-type felsic rock classification (Hart, Gibson and Lesher 2004). This discrimination is more often plotted on a La/Yb(ch) versus Yb(ch) discrimination diagram. The principle is that FIII-type felsic rocks have relatively flat chondrite-normalized REE patterns noted also by enriched HREE patterns.

- < 20 F-1 TYPE
- 20 - 50 F-II TYPE
- > 50 F-III TYPE

Zr/Ti – Measures temperature of melting (e.g., Piercey et al. 2008) and/or degree of fractionation (e.g., Barrett and MacLean 1994) in a felsic melt. Chemostratigraphy is required to determine which factor is influencing the Zr/Ti ratio. In the Winston Lake greenstone belt, this ratio was useful in identifying the high Zr/Ti "Main" felsic unit.

- < 0.3 Low T, less fractionated
- > 0.3 High T, more fractionated

Lithology Legend

See P3776 Lithology Legend.pdf file in LEGEND_Map P.3776 folder.

Using Data with ESRI® ArcGIS® 10.1 and 8.3 and ArcReader®

The geodatabase and shapefiles were prepared with ESRI® ArcGIS® 10.1 software and may be fully accessed using ESRI® ArcGIS® 10.1 and ArcGIS® 9.3. The shapefiles can be accessed by most current GIS software.

Additional files are provided with which some of this information may be examined with free download viewing software including ESRI® ArcReader® (*.pmf* file extension).

Link to free viewer software download site: http://www.esri.com/software/arcgis/arcreader/download.html [accessed July 6, 2015]

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