METAL EARTH

Metal Earth Geochronology Compilation: Superior Craton and surrounding area

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Canada

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1. Summary

This publication contains a compilation of publicly available geochronology data across the Superior Craton in eastern Canada and the north-central United States. The sources of these data include the Manitoba Geological Survey (MGS), the Ontario Geological Survey (OGS), the Ministère des Ressources naturelles (MERN), the Geological Survey of Canada (GSC), the U.S. Geological Survey (USGS), doctoral dissertations, and personal compilations.

The compilation of geochronology data described here includes >9500 sample points across the Superior Craton, with an additional 7000 sample points in areas adjacent to the craton. Multiple isotopic systems (e.g., U-Th-Pb, Ar-Ar, Rb-Sr, Sm-Nd, Re-Os) and interpretations (e.g., crystallization age, metamorphic age, maximum depositional Age, and cooling age) are represented by this data.

This work has been conducted as part of the Metal Earth project led by Laurentian University, a $104 million applied research project funded by the Canada First Research Excellence Fund and federal/provincial/industry partners. A compilation of reported geochronology data across the Superior Craton will assist in the Metal Earth objective to gain a more thorough understanding of Earth's early evolution and processes that govern differential metal endowment.

2. Overview

2.1 Introduction and Purpose

Provincial and national geological surveys have been collecting geochronological data across the Superior Craton since the 1960's. These collections of data are publicly available in the form of databases and datasets from individual organizations. One issue for researchers and industry geologists has been that this valuable data has been isolated by province. The Superior Craton crosses three Canadian provinces, as well as the U.S. states of Minnesota and Michigan. Hence, to perform geochronological investigations of regions that cross provincial and national boundaries, a compiled dataset of all geochronological information organized by geological rather than administrative boundaries was required. This compilation serves to fill that requirement; to collate the various sources of geochronological data, thereby negating challenges presented by the disparate data formats and reporting styles.

This compilation will have several benefits to current and future research. The visualization of spatial and temporal trends across the Superior Craton will be more thorough, and can be accomplished more easily. This dataset will assist in the identification of areas where additional geochronology studies would be of benefit. Furthermore, by constraining the geochronological knowledge of the Superior craton, the compilation documents the current status of sampling and will allow more effective use of those archived samples moving forward. In the future, as the volume of data increases, thermochronological applications may be possible combining the Ar-Ar, K-Ar, and U-Pb rutile, titanite, monazite, and zircon information.

2.2 Errors and Impediments

With the collation of data from multiple compilations, each containing hundreds of individual original data sources, end users should be aware of potential errors and impediments. This includes typographic errors, spatial conversion errors, missing sample ID's, and record duplication.

2.2.1 Typographic Errors

Data entry for the individual survey geochronology compilations consists of either manual data entry or input from optical character recognition software. In either instance, it should be assumed that there is some unknown typographic entry error rate in all of the fields present within this compilation. In rare cases, typographic errors with actual ages have been observed, although these are very rare. Ages that seem unusual should be checked with the original reference.

2.2.2 Spatial Conversion Errors

Prior to 1986, spatial coordinates across the Superior Craton were commonly reported using the North American Datum 1927 (NAD 27). In 1986 the North American Datum 1983 (NAD 83) replaced NAD 27 as the standard datum used for reporting spatial coordinates. It is possible that data entry from reports and publications during this transition overlooked or confused the datum used to report spatial coordinates of the samples described. This could result in errors between 10 – 100 metres (mainly in a north-south sense) when UTM coordinates are converted to the more universal decimal degree format using the World Geodetic System 1984 (WGS 84) datum.

In addition, many of the samples herein were taken prior to regular use of reliable GPS (i.e. prior to approximately 1995). As a result, many samples have been located from paper maps, or maps in publications. This results in a randomized error of anywhere from metres to 10s of kilometres. Such errors are considered rare, but are likely to be present.

2.2.3 Missing Sample ID's

Records without a sample ID in the Metal Earth Geochronology Compilation is a common problem (>1200 instances across the Superior Craton). This issue affects the use of the dataset in several ways, including: limitation of identifying a sample of interest based on the published ID, inability to rapidly identify all duplicate records, and slowing data verification when required. Although this problem is not ideal, given time and resources, sample ID's can be determined by using the other fields of a record (e.g., age, interpretation, reference, etc.).

2.2.4 Record Duplication

Combining multiple compilations that record data from the same region presents issues with record duplication. Ideally this could be avoided by simply comparing the sample ID's that already exist; however, with missing sample ID's and duplicate sample ID's (e.g., #1, A1, sample 1, etc.) the identification of duplicates is a more tedious process. Multiple fields must be utilized to eliminate duplicates, including sample ID, spatial coordinates, age, error, and reference. Typographic errors or variations between source compilations makes this task error prone.

2.3 Submitting Revisions

With the multiple potential sources of error (primarily typographic), end users can help improve the Metal Earth Geochronology Compilation by reporting issues to the compilation administrators. Any report should include a list of the Metal Earth Compilation ID's (MECompID), a description of the issue, and the suggested revision in the form. This information can be sent to metech@laurentian.ca in the form of a spreadsheet or table within a word document. Where revisions apply to geological survey databases (e.g., GeochrON, SIGÉOM, etc.), these will be passed to the individual survey.

2.4 Accessing the Compilation

The Metal Earth Geochronology Compilation can be accessed and downloaded from the Metal Earth Hub. The dataset is available in several formats:

- Spreadsheet (.csv)
- KML file
- Shapefile
- File Geodatabase (.fgdb)

3. Methods

3.1 Data Compilation Sources

Data for the Metal Earth Geochronology Compilation was extracted from a number of geological survey compilations, including the Manitoba Geochronology Database Version 1.7 and 1.8 (Manitoba Geological Survey 2017, 2018), the Geochronology Inventory of Ontario (Ontario Geological Survey 2019), the SIGÉOM database (Ministère des Ressources naturelles 2017, 2020), the Canadian Geochronology Knowledgebase (Geological Survey of Canada 2013), and the National Geochronology Database (Zartman et al. 2003). Additional sources of data include a doctoral dissertation (Bjorkman 2017), government reports (David 2012, Simard 2010), and a personal geochronology compilation (Ayer 2018).

3.2 Data Output

The format of this compilation is summarized in Table 3.1, where all attributes are listed and described. This tabular design was loosely based on the import forms used for the Canadian Geochronology Knowledgebase (Geological Survey of Canada 2013), and the inclusion of relevant geological fields observed in the SIGÉOM database (Ministère des Ressources naturelles 2020).

Table 3.1 Metal Earth Geochronology Compilation attributes and descriptions.

Field Name	Content
MECompID	Unique identifier for each record in this compilation
Sample_No	Sample Name / Number from original source
Age	Geochronology age (Ma) provided by original source
Err_Plus	Geochronology positive error (Ma) provided by original source
Err_Minus	Geochronology negative error (Ma) provided by original source
Age_Interp	Interpretation of age provided by original source
Age_IsoSys	Isotopic system used to determine age
Age_Mat	Material used to determine age
Age_Tech	Technique applied to material
Age_Qualif	Age qualification
Age_Note	Notes related to individual record from original source or compilation
MSWD	Mean Square Weighted Deviation of regression line or weighted mean data
Rock_Type	Simplified lithology of sample
Rock_Desc	Complete lithology description
Geol_Unit	Geological unit sample was extracted from
Geol_Prov	Geological province of sample
Sup_Sbprv	Superior Craton subprovince associated with sample
Geol_Dom	Geological domain of record
Geol_Ter	Geological terrane of record
Lat_DD	Latitude in decimal degrees (WGS 1984)
Long_DD	Longitude in decimal degrees (WGS 1984)
Prov_State	Geographic province / state of sample
Loc_Note	Notes related to location of sample
Ref	Reference for the original publication where the sample was reported
DataSrc	Source of data
SourceID	Unique identifier for each record provided by individual compilations
Lab_No	Lab identification number related to GSC records

3.3 Data Visualization

In collating multiple geochronology compilations and providing a consistent format, analyzing spatial and temporal trends across the Superior Craton is simplified. The spatial distribution of all data contained in this compilation is displayed in Figure 3.1. A second figure displaying a filtered dataset of U-Pb Igneous Crystallization ages within the Superior Craton is displayed in Figure 3.2. More systematic probability density plots across large geological regions that cross provincial boundaries are now possible.

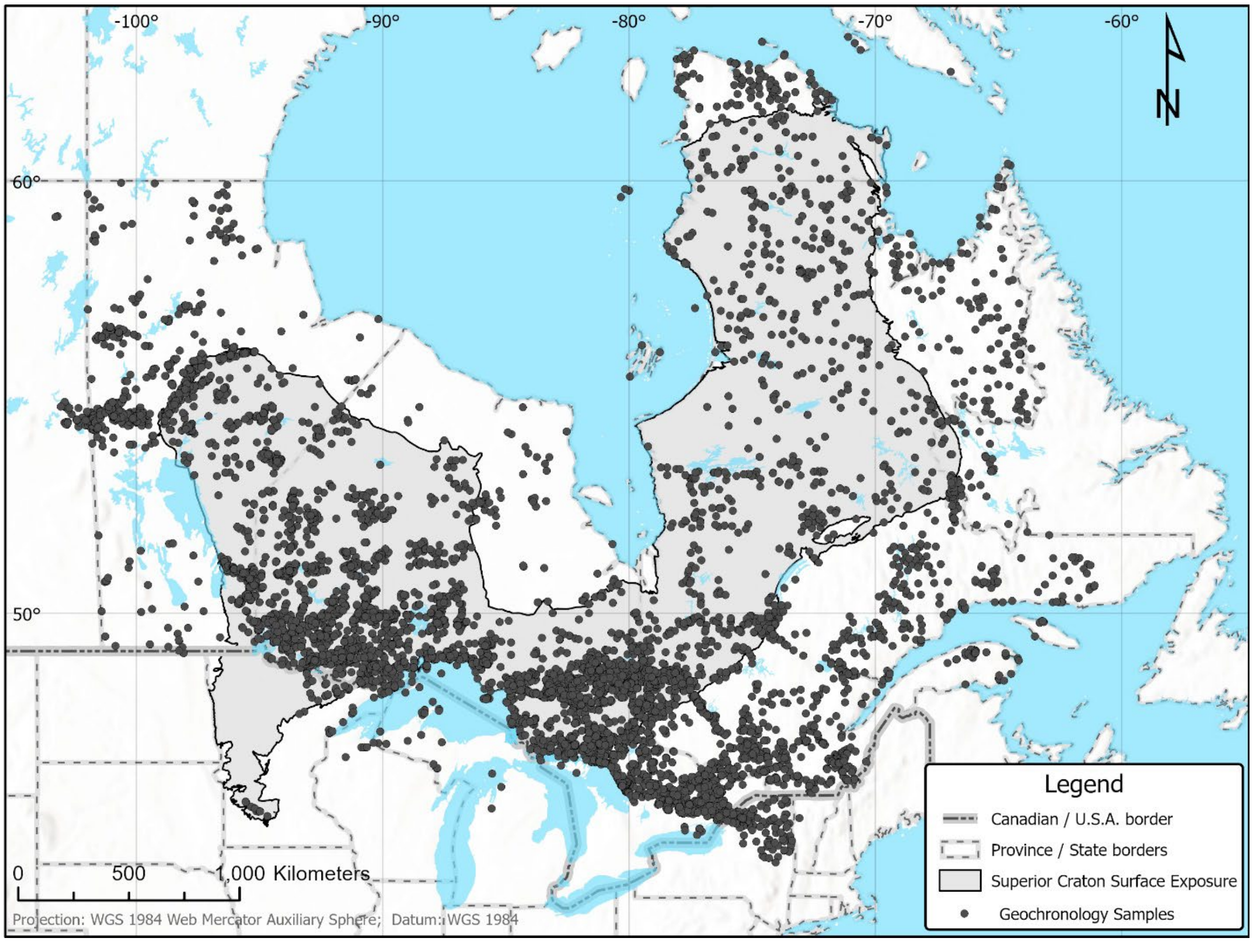

Figure 3.1 Spatial Distribution of all geochronology data in this compilation (n=17,102) both within the Superior Craton and adjacent to the craton. This includes all isotope systems and age interpretations.

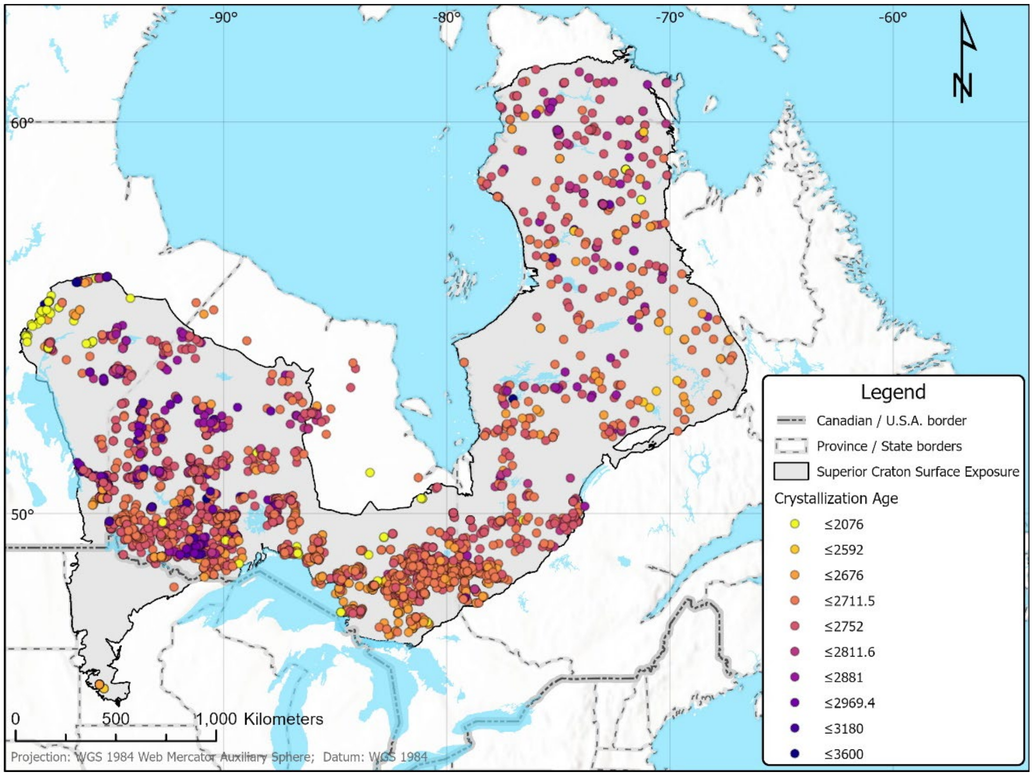

Figure 3.2 Spatial distribution of all Zircon U-Pb Igneous Crystallization ages across the Superior craton (n=3277).

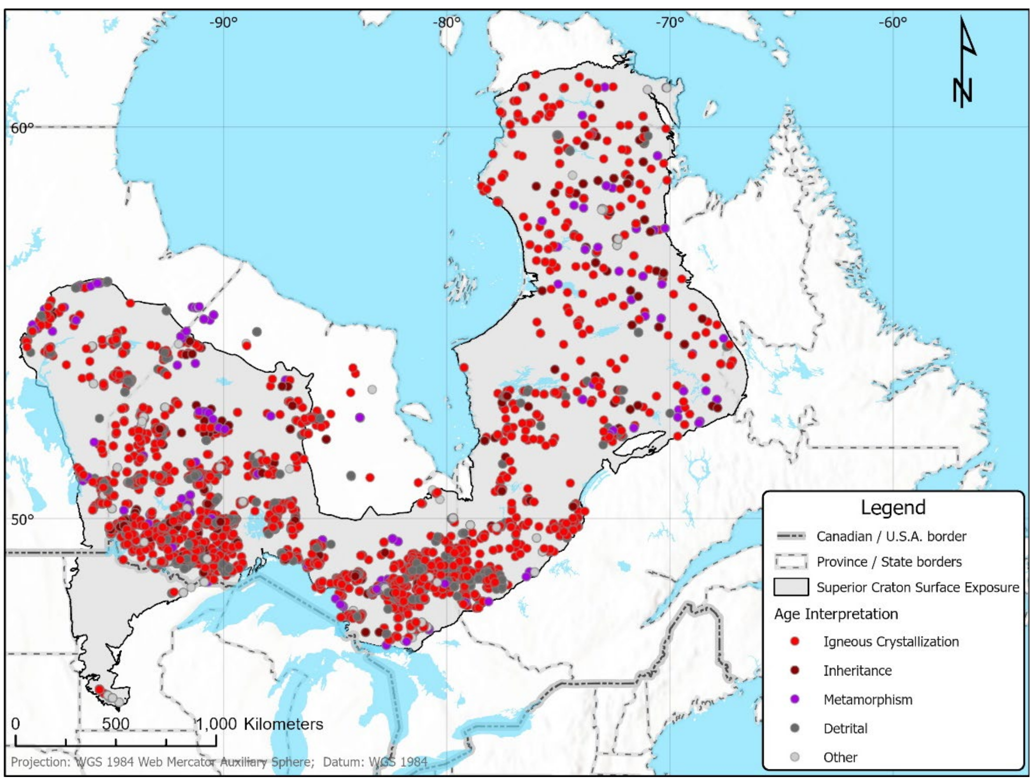

Figure 3.3 Spatial distribution of all Zircon U-Pb Age Interpretations across the Superior craton (n=5453).

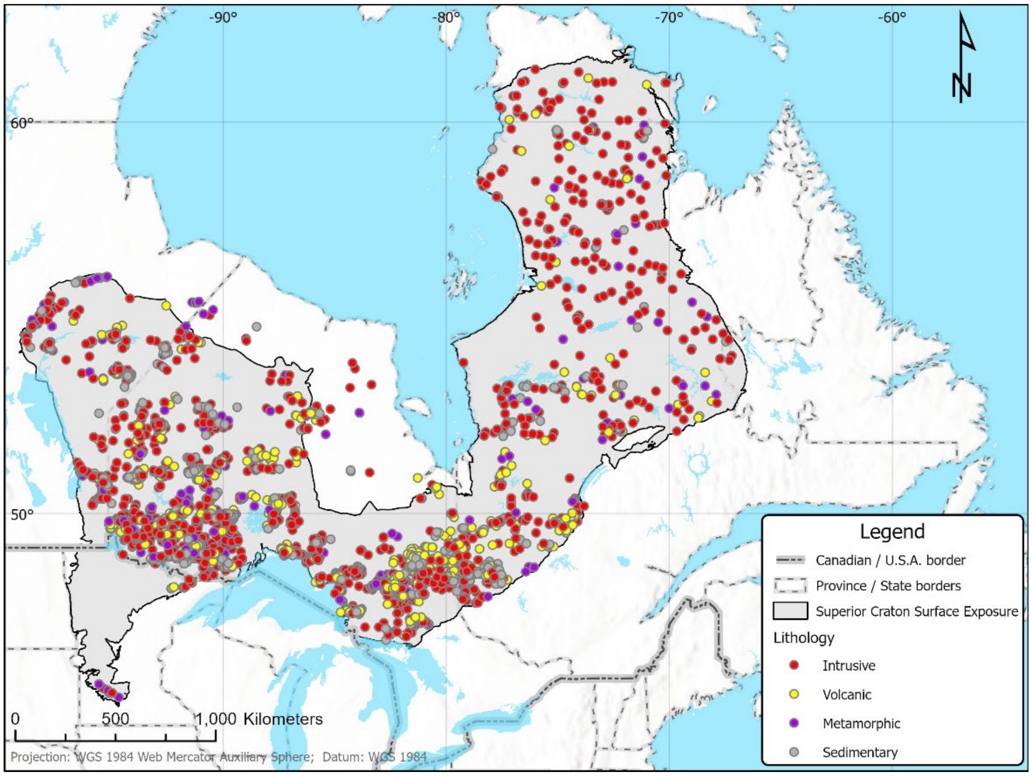

Figure 3.4 Spatial distribution of all Zircon U-Pb Lithologies across the Superior craton (n=5519).

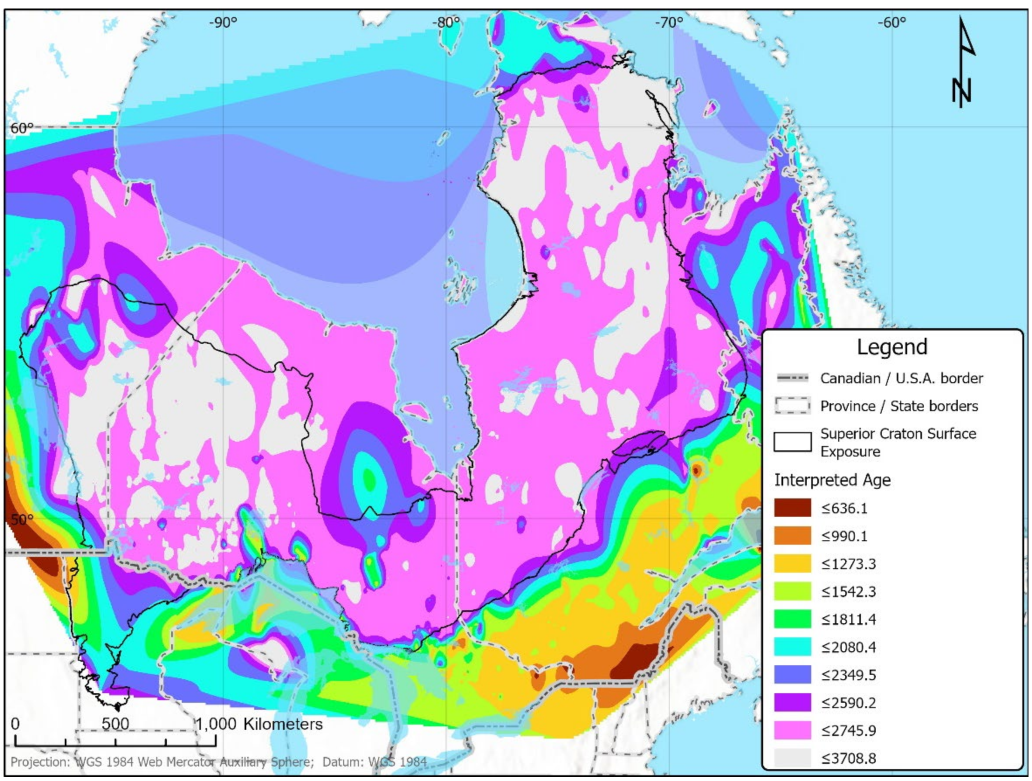

Figure 3.5 Contour map created using filtered data from this compilation (U/Pb Zircon – intrusive, metamorphic and volcanic rock – igneous crystallization and inherited ages). Contouring was performed in ArcGIS using Spatial Analyst using the Natural Neighbor function, with groupings designated by natural breaks (Jenks) statistics.

4. Discussion

This compilation marks the first-time geochronology from across the entire Superior Craton has been collated and made available in a systematic curated compilation. The intention of this dataset is to provide a valuable large-scale ‘perspective’ dataset for stand-alone analysis, and also for comparison with new geochronological data, in the search for similarities or differences across large areas. In presenting a consistent format for data reported across the Superior Craton, comparison and analysis of geochronological trends and systems across the craton, subprovinces, domains, or terranes is simplified and more efficient. The Metal Earth Geochronology Compilation provides a solid foundation for analysis of new data and planning new projects.

As this dataset grows, and as the number of isotopic systems and minerals used increases, the potential for its use as a large-scale geothermometry tool to investigate time-space changes in tectono-thermal events, such as uplift, will increase. Understanding temperature variations over time and space could have important implications for the origin and evolution of large-scale hydrothermal systems and associated ore bodies.

Ultimately, in conducting new fundamental research on the evolution of the Canadian shield and its ore deposits, the Metal Earth project intends to provide important foundational datasets that will aid academic and industry geoscientists in the pursuit of greater understanding of the Superior Craton. The Superior Craton Geological Compilation (Montsion et al. 2018) was the first step in that goal, and this geochronology compilation is intended to work alongside and in conjunction with that craton-wide geological map.

This compilation will be updated yearly for the duration of the Metal Earth project, to ensure the dataset remains relevant. Updates will include newly published data across the Superior Craton from provincial surveys, publications and theses. Geochronological data produced as part of the Metal Earth project will be published by individual research associates and graduate students, which will then be incorporated into this compilation.

5. Additional Resources

Provincial and national geological surveys, and some universities, have built dedicated online resources where the latest geological, geochronological, and geochemical data can be viewed and downloaded. The value of such data may be increased when used alongside the new compilation presented here. Some of these resources are below:

- Quebec Geological Survey (MERN): SIGEOM - http://sigeom.mines.gouv.qc.ca/signet/classes/I1102_indexAccueil?l=f
- Ontario Geological Survey: OGS Earth - https://www.mndm.gov.on.ca/en/mines-and-minerals/applications/ogsearth
- Manitoba Geological Survey: Map gallery - https://web33.gov.mb.ca/mapgallery/mgg-gmm.html
- Geological Survey of Canada (GSC) – The Atlas of Canada - https://www.nrcan.gc.ca/maps-tools-and-publications/maps/atlas-canada/10784
- Saskatchewan Isotope Laboratory (SIL): DateView (geochronology) and StratDB (lithostratigraphy, structural domain, and ore deposit) databases - https://sil.usask.ca/Databases.htm
- Geoscience Australia (GA) data delivery point – for comparison to Australian geoscience data - http://www.ga.gov.au/geochron-sapub-web/geochronology/shrimp/search.htm

6. Acknowledgements

The authors would like to thank Bill Davis (GSC) for sharing a geochronology data input template that was used as a guide to the current list of fields populated in the Metal Earth Geochronology Compilation. Mike Easton (OGS) helped improve this compilation in rectifying problematic sample points across Ontario and building the OGS GeochrON database. Jean Goutier (MERN) assisted in the identification of published resources in Quebec. Christian Bohm (MGS) provided assistance in identifying geochronology resources from the MGS. Phil Thurston and John Ayer (LU) provided helpful comments and suggestions that improved the quality of the compilation. We also acknowledge previous Metal Earth GIS Specialists Rebecca Montsion, Jacqueline Edwards, and Ryan Paquette for their efforts in starting this compilation. We would also like to thank the geological surveys across the Superior Craton for realizing of the value of geochronological data and their contribution of knowledge spanning many decades. Financial support was provided by Canada First Research Excellence Fund (CFREF), Northern Ontario Heritage Fund Corp., and the Mineral Exploration Research Centre (MERC).

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