GS2021-1

Updates to the Manitoba Mineral Deposits Database, east-central and northwestern Manitoba (NTS 53E, F, 64J, K, N, O)

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Summary

The Manitoba Geological Survey began work to update Manitoba's Mineral Deposits Database (MDD) in 2020. Continued efforts during the past year have led to the preliminary identification of 22 070 new occurrences with relevant geochemical data in Manitoba, encompassing a wide range of commodity types. In this report, recent changes to the methods and definitions used for the MDD update are outlined and a summary of occurrences added so far to NTS areas 53E, F, and 64J, K, N and O is provided.

In Brief:

- Approximately 22 000 new mineral occurrences have been tentatively identified in Manitoba
- Findings include high-grade gold and graphite occurrences in the Island Lake region, and significant rare-earth element and uranium occurrences in northwestern Manitoba
- Updates are being released in batches by region; Island Lake region (NTS 53E, F) updates are completed, and northwestern Manitoba (NTS 64J, K, N, O) is in progress

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Introduction

Accurate and comprehensive mineral occurrence data are necessary to inform land-use plans, mineral development strategies and related assessments of critical mineral potential in Manitoba. Because mineral occurrence data are also used by the minerals sector to guide their exploration decisions, the identification of new (or previously unrecognized) mineral occurrences can spur industry investment in underexplored regions. The MDD, which serves as the primary inventory of mineral occurrence data in Manitoba, was therefore identified as a priority for updates starting in 2020.

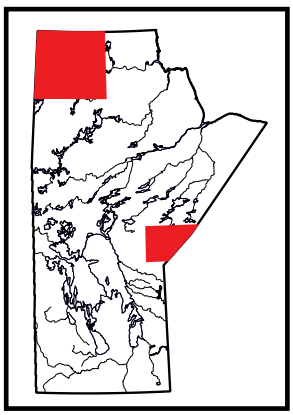
Prior to this year's updates, the latest version of the MDD was published in 2009 (Conley et al., 2009), containing a total of 2760 occurrences in Manitoba. The rationale and methods used to improve the MDD are explained in Rinne (2020). In this report, changes to the methods employed to update the MDD since last year are summarized, notably including the introduction of software to assist or partially automate the extraction of mineral occurrence information from historical reports. A brief overview of occurrences recently added to parts of the Island Lake region and northwestern Manitoba is also provided.

Definitions and methods

Mineral occurrence grade criteria

Terms used to classify entries in the MDD include 'mineral occurrence', 'mineral deposit' and 'discretionary occurrence', as defined in Rinne (2020). Most mineral occurrences are identified based on geochemical results, where values exceed a defined minimum in a rock sample. The minimum values used have been updated since 2020 and are listed in Table GS2021-1-1.

Although many of the minimum grade requirements were initially based on those defined in Ontario's equivalent database (Ontario Mineral Deposit Inventory; Ontario Geological Survey, 2020), several have since been adjusted based on the issues discussed below. Minimum grade criteria for the MDD have also been expanded to include a wider range of commodities not normally captured in equivalent databases for other jurisdictions.



The general aim in defining minimum occurrence values is to capture any results or observations that could reasonably be associated with (or form distal to) mineral deposits, without flagging too many irrelevant and/or background results. A purely statistical approach—for example, a value exceeding three standard deviations above mean crustal abundance—was found to be inappropriate for this purpose. Instead, most of the minimum values are based on the geochemistry of known ore deposits, with minimum values typically between half and one fifth of deposit grades globally. Exceptions to this guideline are generally intended to capture results that might indicate potential for other commodities. For example, 500 ppm Bi is lower than 1/20th of values typical in bismuth ore deposits, but bismuth contents of 500 ppm could mark the distal portions of some gold-mineralizing systems (e.g., Kadel-Harder et al., 2021). Similarly, 1% F is lower than 1/10th of most known fluorine deposit grades (Hayes et al., 2017), but is considered an occurrence in the

Table GS2021-1-1: Minimum grade or mineral criteria for occurrence classification in the Manitoba Mineral Deposits Database.

Commodity	Minimum grade or mineral content for occurrence classification
Ag	>35 ppm (>1 opt[1])
Au	>0.5 ppm (>0.015 opt[1]) OR visible gold
Al	Bauxite or gibbsite present
As	Evaluation[2]
B	>10 000 ppm (>1%) OR minerals present (e.g., ulexite, borax)
Ba	>30 000 ppm Ba OR >5% barite
Be	>50 ppm OR minerals present (e.g., beryl, bertrandite)
Bi	>500 ppm
Graphite	>5% OR present as coarse flakes or seams
Co	>200 ppm
Coal (metallurgical)	Evaluation[2]
Cr	>10 000 ppm (>1.5% Cr_2O_3)
Cs	>1000 ppm OR minerals present (e.g., pollucite)
Cu	>2500 ppm
Diamond	Mineral present
F	>1% F OR >2% fluorite
Fe	>12.5% (>16.1% FeO or >17.9% Fe_2O_3) AND unit >5 m thick
Ga	>100 ppm
Ge	>30 ppm
Gypsum	>40%
He	>0.3 mol % (from natural gas production)
Hf	>150 ppm
In	>5 ppm
Li	>1000 ppm Li (>0.2% Li_2O) OR minerals present (e.g., spodumene, lepidolite, petalite) OR >30 ppm Li in brines
Mg	>10% magnesite ($MgCO_3$) OR >15% brucite ($Mg(OH)_2$) OR >10% carnallite
Mn	>50 000 ppm (>6.5% MnO)
Mo	>200 ppm
Nb	>200 ppm OR minerals present (e.g., columbite, pyrochlore)
Ni	>800 ppm
Pb	>10 000 ppm
PGE[3] (Pt+Pd+Rh+Ir+Ru+Os)	>0.5 ppm total PGE
P	>10% P_2O_5
Potash	>7.5% potash
Rb	>1000 ppm
Re	>10 ppm
REE[4] (lanthanides + Sc, Y)	>0.3% total rare-earth oxides OR minerals present (e.g., monazite) OR La, Ce, Nd, Sc, or Y >500 ppm OR Pr, Sm, Gd, Dy, Er, or Yb >50 ppm OR Eu, Tb, Ho, Tm, or Lu >10 ppm
Sb	>500 ppm
Se	>100 ppm
Silicon	Quartzite >5 m thick OR high-purity silica sand
Sn	>1000 ppm
Sr	>50 000 ppm (>5%) OR minerals present (e.g., celestite)
Ta	>100 ppm OR minerals present (e.g., tantalite, pyrochlore)
Te	>100 ppm
Th	>250 ppm OR minerals present (e.g., monazite)
TiO_2	>7.5% (>45 000 ppm Ti)
Tl	>100 ppm
U	>250 ppm (>0.03% U_3O_8) OR minerals present
V	>1000 ppm
W	>500 ppm
Zn	>1000 ppm
Zr	>5000 ppm
Other (carbonatite, kimberlite and related rocks, semi-precious gemstones, high-purity limestone, etc.)	Evaluation[2]

[1] Troy ounces per short ton
[2] Requires review by a geologist to determine whether the occurrence is significant
[3] PGE, platinum-group element
[4] REE, rare-earth element

MDD because it may indicate potential for Nb or rare-earth element (REE) mineralization in some rocks.

Some commodities (e.g., Ga, Ge, In, Rb, Se, Te, Tl) are extracted mostly or exclusively as byproduct from other ores. In those cases, values are based on limited information reported for ores of the relevant deposits. Finally, some commodities have strictly metallurgical/mineral criteria. For example, there is no minimum grade specified for an aluminum occurrence; an occurrence would instead be noted where the presence of bauxite or gibbsite has been documented.

Further adjustments to the values in Table GS2021-1-1 may be necessary in the future, perhaps in response to significant changes in market prices, development of new metallurgical techniques, or other aspects that are difficult to forecast. In any case, users of the updated MDD should note that geochemical values are recorded in new occurrence entries; users can therefore filter the occurrence data to increase the minimum grade requirements if desired.

Data collection methods

The general approach to the MDD updates remains the same as described in Rinne (2020). The aim is to capture key occurrence characteristics as quickly as reasonable, including a compromise to omit several of the more detailed fields (e.g., detailed geological descriptions, exploration history) in new mineral-occurrence entries.

As MDD updates progressed through 2020 and the number of new occurrences increased beyond what was initially expected, it became clear that a fully manual compilation of occurrences from all assessment files in Manitoba would be an unreasonable task. Last year, much of the project work was therefore devoted to investigating software tools that could partially automate or assist in the identification of mineral occurrences. The results of this work are summarized below.

Optical character recognition

Nearly all PDF reports in the Manitoba Mines Branch Assessment Library comprise scanned images that lack embedded text data. Optical character recognition (OCR) is therefore necessary to process the report contents. Several OCR tools were tested using a series of representative assessment-file pages that include poor-quality scans, handwritten drill logs and large tables. Amazon Textract® and ABBYY FineReader® were found to produce the most consistently useful results.

Phrase matching

Some mineral occurrences are reported only in the main text of assessment files, in phrases such as “coarse graphite from 27 m to 53 m,” “visible gold in sample 3423,” or “carbonatite dikes.” Reading through the main body of an assessment file to identify such phrases is one of the most time-consuming parts of the MDD update. Results so far indicate that this step can be partially automated using indexing and search software (e.g., dtSearch®) to flag any matches from a list of specific terms or phrases in each report.

To account for natural language variations, search terms applied to the assessment files include a combination of fuzzy and proximity matching, wildcard characters and other expressions. For example, using dtSearch® syntax, a search for “coarse& w/3 graphit*” will flag any occurrence of ‘graphite’ or ‘graphitic’ within three words of ‘coarse’ or any of its synonyms. Likewise, having ‘fuzzy search’ enabled for the term ‘spodumene’ will flag mentions of spodumene along with typos or OCR errors such as ‘spoqumere’.

Preliminary applications of these text searches have led to rapid identification of some graphite and gold occurrences in reports from the Island Lake region. However, continued work with these search results has required several iterations/adjustments to the strings used, mostly to reduce false positives as well as the amount of time needed for a human to page through the search hits in each set of reports. Because of the large number of commodities and related search terms involved, the current list of search phrases is a work in progress.

Table data

Most of the mineral occurrences encountered in the assessment files to date were found in geochemical results or assay-data tables, typically in appendices. Identifying occurrences in these tables is a generally straightforward exercise in finding values that exceed the occurrence minima listed in Table GS2021-1-1. However, the process can be time-consuming, particularly in the case of large tables spanning multiple pages, or in cases where sample standards are not clearly indicated.

Attempts to automate the process of extracting occurrence data from tables have yielded promising results. Provided large or high-quality scans of tables in reports with an OCR text layer, an open-source tool called Tabula is used to extract tables as CSV files from PDF documents. Values exceeding a given number are then easily identified in each table. Unfortunately, many of the scanned report tables contain small or low-resolution text that hinders the accuracy of OCR results, to the extent that confirming occurrence results often takes longer than simply reading the table in the original scan.

In addition to the work described above, several of the more recent assessment files were originally submitted with geochemical results in digital format such as Excel® tables. A total of 3720 such files have been retrieved and sorted. Occurrences contained in these tables are being processed by NTS area.

Occurrence-location data

After each occurrence identified in text or table results is manually confirmed to be valid (to exclude the results of e.g., faulty OCR or elevated assay values from sample standards), further work is then required to determine the occurrence location. Because co-ordinates are rarely included in older reports, most of this work involves georeferencing of sample location maps. The lower scan quality of the assessment file PDF documents often requires retrieving the original document to then find the locations of specific sample numbers on large-format maps. This stage of the process is understandably time-consuming and represents the last step prior to the public release of new occurrence data. Although some interesting work has been published regarding automated georeferencing of maps (e.g., Arriaga-Varela and Takahashi, 2019), it is not yet clear how easily this can be incorporated into the MDD update process.

Results to date

At the time of writing, 22 070 new occurrences have been tentatively identified from assessment file tables and text. This represents a significant increase from the previous version's 2760 total occurrences (several of which are minor and are being removed during the database update). More occurrences are anticipated as text searches continue to be carried out through assessment files, and as other sources of data (e.g., Manitoba Geological Survey [MGS] geochemistry results) are incorporated into the database updates.

Some of these new occurrence data are available in MGS Data Repository Item DRI2021019[1] (Rinne, 2021), which contains results from NTS areas 53E and F. Publication of the remaining results first requires confirmation of each finding, along with the above-described process of locating each occurrence. Attempts to use the centre of each assessment-file polygon as a provisional location estimate were found to be potentially misleading, as many of the assessment areas are very large. Further update releases will therefore proceed by region, after location data have been entered.

In addition to the published mineral-occurrence data from NTS areas 53E and F (Rinne, 2021), location data entry is partially completed for NTS areas 64 J, K, N and O. The results for both these regions are described below.

NTS areas 53E and 53F

Much of the Island Lake domain of the northern Superior province is included in NTS areas 53E and 53F (Figure GS2021-1-1). Since beginning the MDD update in 2020, a total of 348 mineral occurrences were added to NTS areas 53E and 53F, and a further 27 existing occurrences were updated, mostly with the addition of relevant geochemical data (Rinne, 2021). Twenty-five occurrences in the previous version of the MDD were removed from the region, as they were deemed trivial findings (such as occurrences of sulphide-facies iron formation or pyrite veins with no significant assay results).

Among the new occurrences provided in Rinne (2021), a few notable examples are described below, numbered as shown in Figure GS2021-1-1:

1) Gold, copper, and tellurium occurrences added near Willow Lake include findings of visible gold, tetradymite, and grades of up to 374 ppm Au in quartz veins (Assessment Files 91149, 93215 and 94339, Manitoba Agriculture and Resource Development, Winnipeg).

2) Several mineral occurrences were added near the eastern shore of Bigstone Lake, including multiple zinc occurrences, drillcore samples with elevated nickel and palladium contents, intervals of 'well-mineralized to near-solid graphite', and one unconfirmed finding of wolframite. Also nearby are the Diamond Queen gold veins discovered in the 1930s (Assessment File 91148) along with a related series of veins discovered in 2017, with several surface samples containing >30 ppm Au (Rinne, 2017).

3) New gold occurrences were added along an east-southeast trend in the eastern half of the Bigstone Lake greenstone belt, along with several potentially significant intersections of graphite in drillcore (based on logs describing 'solid graphite', 'mineralized graphite', or '25–40% graphite' over intervals up to 8 m thick).

4) Occurrence data were added in the vicinity of the Bella Lake pluton. The area contains chalcopyrite, bornite and molybdenite in veins of quartz, potassium feldspar and biotite, within a zone of potassic alteration surrounded by propylitic alteration (Assessment File 90001). Although Archean porphyry deposits are rare, these sulphide- and alteration-zonation features are broadly consistent with porphyry-style mineralization (e.g., Sillitoe, 2010).

5) A series of previously undocumented occurrences were added (and several existing occurrences updated) along an east-southeast trend from the Island Lake mine into Sagawitchewan Bay. These occurrences include values of up to 145 ppm Ag, 301 ppm Au, 0.78% Cu, 760 ppm Mo, 1400 ppm Ni, 2.83% Pb, 3155 ppm Sb, 1470 ppm W and 7.06% Zn, along with occurrences of abundant graphite in drillcore.

6) Assay data reported from surface sampling near Rose Lake in 1980 include results of 0.5 ppm Au, 0.06% Co, 1.94% Cu, 0.75% Ni, 0.48 ppm Pd and 0.41 ppm Pt (Assessment File 92726). Earlier drilling in the area (1961) intersected sul-

[1] MGS Data Repository Item DRI2021019, containing the data or other information sources used to compile this report, is available online to download free of charge at https://www.gov.mb.ca/iem/info/library/downloads/index.html, or on request from minesinfo@gov.mb.ca, or by contacting the Resource Centre, Manitoba Agriculture and Resource Development, 360–1395 Ellice Avenue, Winnipeg, Manitoba R3G 3P2, Canada.

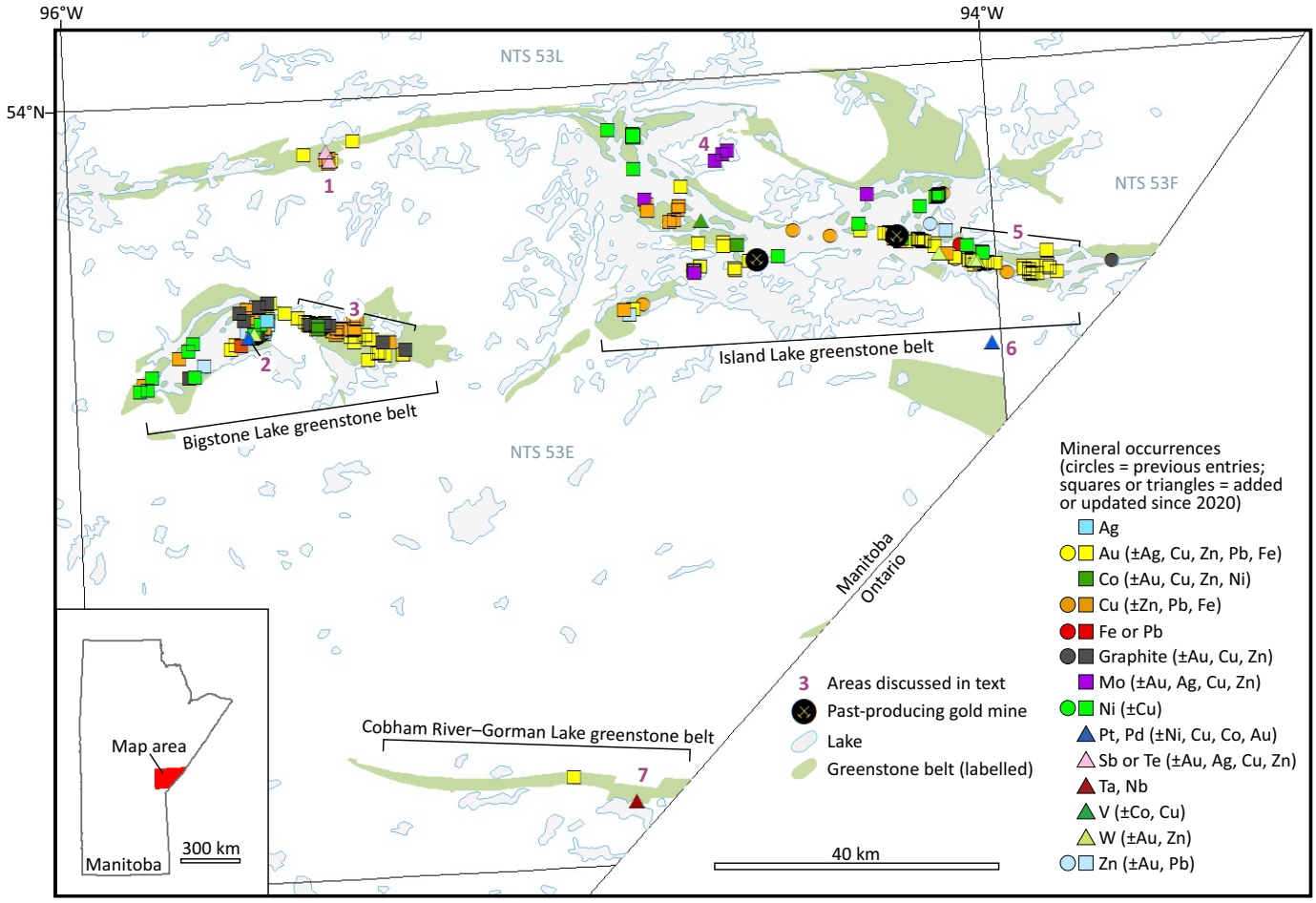


Figure GS2021-1-1: *NTS areas 53E and 53F showing mineral occurrences, including new data added to the Manitoba Mineral Deposits Database since 2020.*

phide-mineralized pyroxenite and gabbro, but no assays were reported.

7) Tantalite, columbite and tourmaline were reported by Quinn (1960) near the northeastern shore of Gorman Lake; this showing lacks geochemical data and has been classified as a discretionary occurrence.

NTS areas 64J, K, N and O

The NTS areas 64J, K, N and O occupy the northwestern corner of Manitoba (Figure GS2021-1-2), including parts of the Wollaston basin and Seal River domain. This year, a total of 916 mineral occurrences were added to the region, including relevant geochemical data. A further 427 occurrences have been tentatively identified from assessment files but are pending confirmation and location information. Many of the new occurrences, including several of the high-grade uranium findings, correspond to boulder samples and are identified as such in the MDD entries. Most of the occurrences in the original MDD (marked with circle symbols in Figure GS2021-1-2) have not yet been evaluated in detail, and some may be removed as updates continue.

Most of the preliminary occurrence data added this year are clustered in areas discussed below (areas numbered as shown in Figure GS2021-1-2):

1) Uranium-mineralized boulders in areas southeast of Brandson Lake returned values of up to 6553 ppm U (Assessment Files 93420 and 93494).

2) Areas east of Putahow Lake contain elevated U and Th in outcrop (up to 597 ppm U and 537 ppm Th) and in drill-core (up to 0.085% ThO_2 and 0.065% U_3O_8; Assessment Files 92136 and 92212).

3) A total of 240 occurrences were added to areas west and southwest of Snyder Lake. Results from samples in this area include values of up to 4040 ppm Mo, 2.16% Th, 9.30% U and 8145 ppm total rare-earth elements (REE; Assessment File 74417). Phosphorus and beryllium contents are also locally elevated, with samples returning up to 13.6% P_2O_5 and 200 ppm Be.

4) Geochemical data and new occurrence locations were added to areas south and west of Munroe Lake, including surface and shallow-outcrop drill-sample results of up to

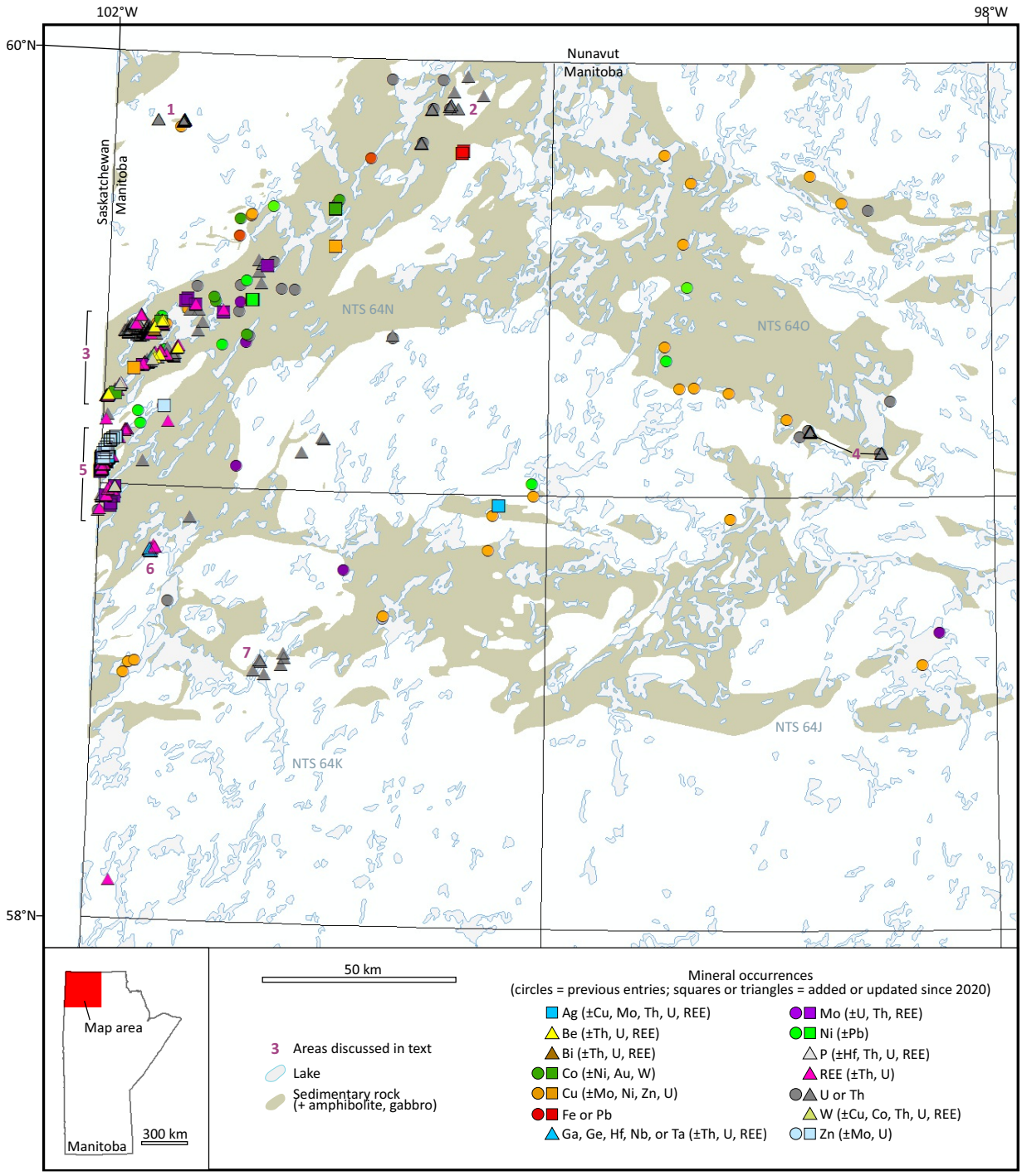


Figure GS2021-1-2: *NTS areas 64J, K, N and O showing mineral occurrences, including new data added to the Manitoba Mineral Deposits Database in 2021.*

1.43% U and 1009 ppm Th (Assessment Files 92143 and 92137).

5) A total of 327 occurrences were added to areas north and south of Allnutt Lake. In addition to widespread anomalies of uranium and thorium (up to 3.22% U and 1.52% Th), boulder sampling in this area returned many significant REE and Mo values (up to 9.1% total REE—including 3.8% Ce and 1.8% La—and 5.5% Mo; Assessment File 74417). A series of zinc occurrences is also evident along a northeast trend near the Saskatchewan border (Figure GS2021-1-2), with Zn contents of up to 5900 ppm from surface, and up to 2400 ppm in drillcore (Assessment Files 74417 and 90211). South of Allnutt Lake, hafnium and phosphorus occurrences include values of up to 553 ppm Hf and 14.1% P_2O_5.

6) Several samples containing >5% total REE were added near the southwestern shore of Misty Lake, including one sample with 10.5% total REE (or approximately 12.3%

total rare-earth oxides; Assessment File 74417). Some of the samples also contain elevated Ga (up to 113 ppm) and Hf (up to 295 ppm). Although the MDD did not previously include any occurrences in this area, Kremer et al. (2010) did comment on the "significant potential for high-grade U and REE deposits" in the region.

7) A series of boulder samples collected from an area north of Peacey Lake contain elevated thorium contents (up to 0.08% ThO_2; Assessment File 93419).

Economic considerations

Current results of the MDD update project highlight the value of data hidden in historical datasets such as industry assessment reports. Among the mineral occurrences added to parts of northwestern Manitoba and the Island Lake region, several warrant emphasis in mineral-potential assessments, and may directly inform related land-use planning, future survey activities, or mineral-sector investment decisions. Examples of significant findings not featured in the previous version of the MDD include the above-described high-grade gold, Ni-Cu-Pt-Pd and graphite in the Island Lake region, and high-grade REE and uranium in northwestern Manitoba. These new results can be filtered or classified by grade, as relevant geochemical data are included in all new MDD entries.

Critical minerals, including resources required for low-carbon technologies such as batteries and solar panels, are anticipated to play an increasing role in the Canadian economy (Natural Resources Canada, 2021). In addition to the above-mentioned occurrences of REE, graphite and platinum-group elements, new critical-mineral occurrences identified in parts of Manitoba so far include findings of antimony, bismuth, chromium, cobalt, copper, gallium, germanium, molybdenum, nickel, niobium, tantalum, tellurium, tungsten, vanadium and zinc. Many of these occurrences were effectively ignored in the historical reports and it is expected that continued MDD updates will lead to improved understanding of critical-mineral potential in Manitoba.

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