SLAVE GEOLOGICAL PROVINCE MINERAL POTENTIAL STUDY
GIS Multi Criteria Analysis

Slave Craton, NWT & NU, Canada

Report Submitted: 31 March 2019

Prepared for:

Northwest Territories Geological Survey
GNWT Industry, Tourism, and Investment
Mineral Resource Planning Division

Prepared by:

AURORA GEOSCIENCES

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

1 ACKNOWLEDGEMENTS

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2 DISCLAIMER

This report is based on the subjective judgements of several geoscientists. Judgements were made using limited information sources. Any subjective, knowledge-based assessment will be handicapped by various limitations and biases, and these should be recognized. A subjective analysis will be strengthened by the input of additional knowledgeable geoscientists.

The end product is a map showing interpreted mineral potential of the Slave Geological Province and surrounding region. It should not be used solely, but in conjunction with other materials, whether for deciding road routes or for planning mineral exploration programs. Nor should this be considered a static document. New information arises from ongoing and future exploration results, new geological compilations, and the always-changing land tenure situations. The user is thus cautioned against applying the mineral potential map too broadly, or in isolation, or very far beyond its publication date.

Note that the maps included in this report have been scaled down from the original 1: 5 000 000 scale plots.

3 EXECUTIVE SUMMARY

In 2013, the Government of the Northwest Territories (GNWT) developed a Mineral Development Strategy (GNWT, 2013) which restated a long-expressed commitment to invest in infrastructure to improve access to mineral potential. A follow-up 2014 GNWT Mineral Development Strategy Implementation Plan (GNWT, 2014) included a directive to undertake a resource access corridor study to help planning and prioritization of infrastructure to support resource development. Aurora Geosciences Ltd. (AGL) was contracted by GNWT to undertake such a study, which was delivered in 2015 (Gal and Martin, 2015).

The current Slave Geological Province Mineral Potential Study (SGMPS) is an update of the 2015 work. The update includes a new and refined bedrock geological compilation for the Slave Geological Province (Stubley, in prep.), updated mineral tenure and mineral occurrence information (focusing on the southern Slave Province south of Lockhart Lake), and a larger group of geological experts (a minimum of six individuals) to perform the subjective evaluations that are part of the process. In addition, geophysical surveys and igneous dyke swarms have been added as factors to be considered in estimating mineral potential.

The primary product is a map illustrating the interpreted highest mineral potential in the Slave Geological Province (SGP). This map is meant to be considered in concert with the results of other studies, in arriving at an optimum road routing. Because the data from which these maps are based are in a state of change, and because they use subjective judgements; the results cannot be considered static or final.

The mineral potential map makes use of two major sets of data: the databases of known mineral occurrences throughout NWT and NU (formerly known as NORMIN and currently still known as NUMIN, respectively), and a new geological compilation of the Slave Geological Province (Stubley, in prep.). Along with mineral tenure and geophysical surveys, these data were evaluated by a panel of experts through mainly subjective means, converted to numerical scores, and through Geographic Information System (GIS) analysis, represented on thematic "heat maps".

The six factors (mineral occurrences, bedrock geology, mineral tenure, geophysical surveys, faults and dykes) were rated against each other in pair-wise comparisons. Relative weightings of importance were obtained for each factor, and these weights were applied through GIS analysis to evaluate every 100 m x 100 m cell in aggregate. The result is a "heat map" displaying interpreted mineral potential based on the six factors (Figure 1).

Using additional GIS analysis functions with the mineral potential raster data, it was possible to obtain a preferred "least-cost" route placement of a road through the areas of mineral potential to a terminus at Lockhart Lake (Figure 2).

The main conclusion from this study is that the interpreted highest mineral potential lies in the volcanic greenstone belts and around known kimberlite clusters. This is unsurprising, given that the bedrock geology factor was weighted quite strongly in this interpretation, and volcanic rocks were considered the most favourable bedrock type, next to kimberlites. The mineral occurrence factor also had a strong weighting; and producing diamond deposits were scored highly as indicators of mineral potential.

A key difference from the 2015 study is that faults are considered much more important for mineral potential. Also, because of the increased number of factors, the bedrock geology and mineral occurrences were not quite so overwhelming as determinants, although they were deemed the greatest importance, and close to each other in relative importance.

The resultant preferred pathway to Lockhart Lake leaves the terminus of NWT Highway #4 (Tibbitt Lake road) and proceeds northward, thence northeastward for 151 km (Figure 2). This preferred path lies more easterly of the preferred route defined in 2015 (Gal and Martin, 2015; Gal et al., 2015).

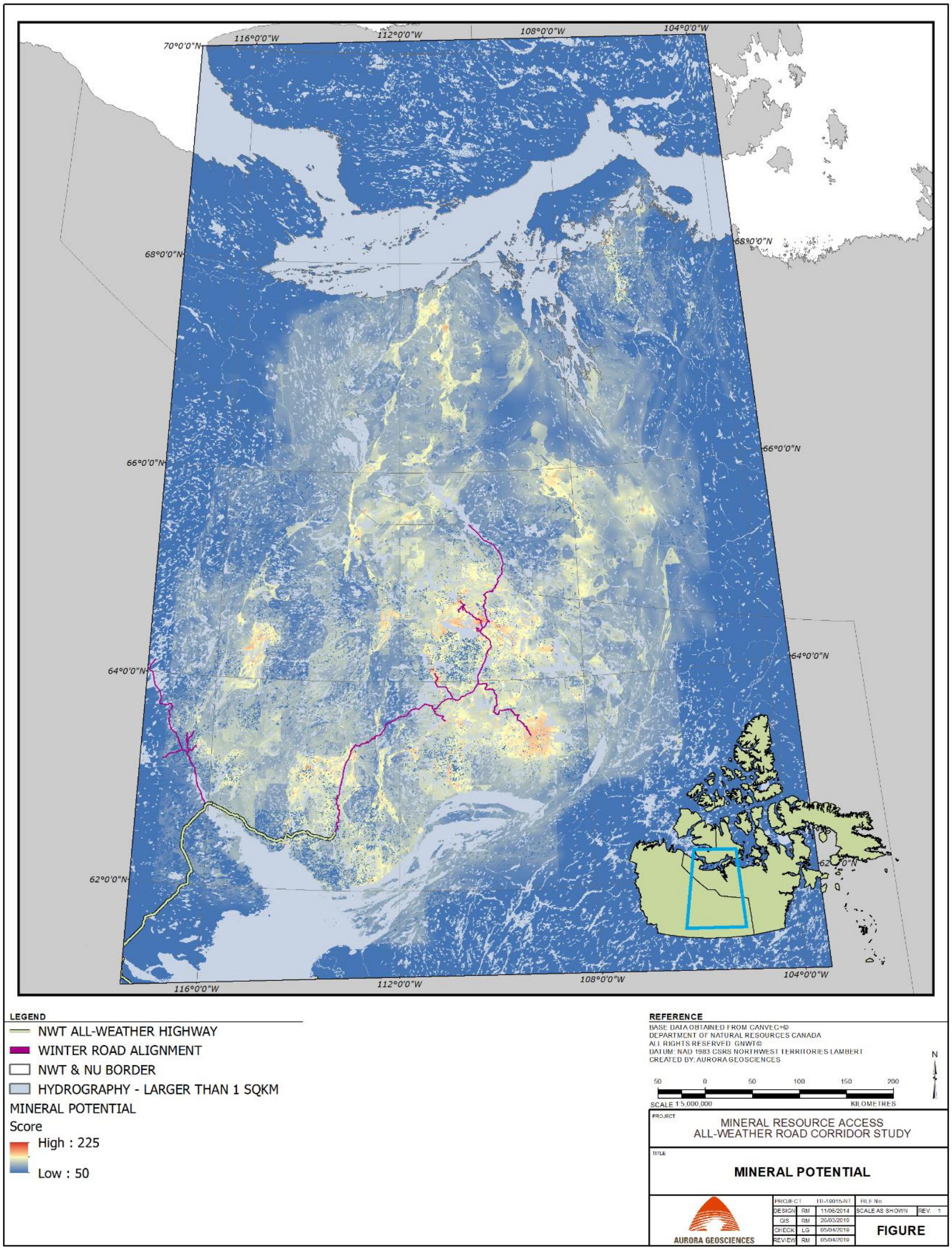

Figure 1. Interpreted Mineral Potential Map. *Interpreted mineral potential of the Slave Geological Province expressed as a heat map. Yellowknife and the existing and proposed NWT Highways system are shown. Higher potential areas are in reds.*

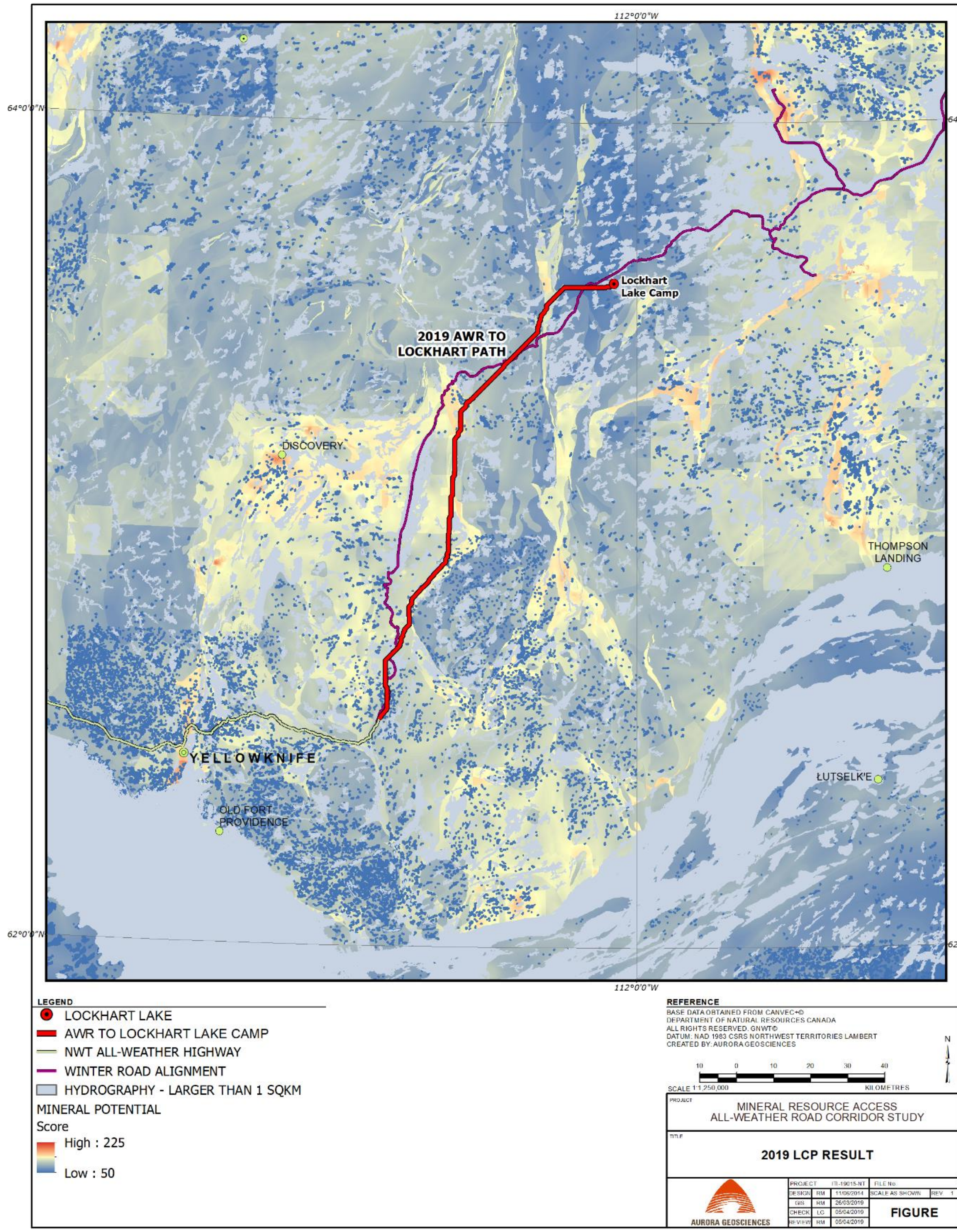

Figure 2. "Least-cost" road routing to Lockhart Lake. *Preferred road route to Lockhart Lake camp from anywhere on the existing NWT Highway system.*

4 INTRODUCTION

This report summarizes a mineral potential mapping project undertaken by Aurora Geosciences Ltd. (Aurora) for the Government of the Northwest Territories (GNWT). The project "Slave Geological Province Mineral Potential Study" (SGMPS) was awarded to Aurora through a Standing Offer Agreement.

Mineral potential is arrived at using an Analytical Hierarchy Process (AHP) through which six variables are individually evaluated and scored, and then compared with each other in a pair-wise manner to calculate relative weightings of importance. Computation of resultant numerical scores throughout a high-resolution raster map of the study area results in colour-coded "heat maps" graphically illustrating the interpreted mineral potential of the Slave Geological Province (SGP). The maps are intended to contribute to road routing decisions.

The mineral potential map is accompanied by the input thematic heat maps of the mineral occurrences, bedrock geology, mineral tenure, geophysical survey coverage, dykes and faults. Surficial geology, hydrology and wetlands, and basic infrastructure maps are also presented. The hydrology and wetlands data are also used as exclusionary layers, to enhance the map depicting optimal road routing to Lockhart Lake.

4.1 BACKGROUND

An all-weather road through the SGP to tidewater in Nunavut has been intermittently considered by GNWT (and/or Federal Government agencies) since the 1950s and by the private sector since at least the 1970s (Arthur Andersen LLP et al., 1999). Currently in the NWT, a network of both public and private seasonal ice roads, branching off from territorial highways #3 and #4, service communities and mines in the SGP.

All weather road proposals originating in Nunavut, such as the Bathurst Inlet Port and Road Project (Hamel, 2013) and the Izok Corridor Project of MMG Limited have seen some level of technical study, and environmental review. As of September 2016, MMG was looking into partnerships with government agencies (MMG website Feb. 24, 2019; mmg.com). The Bathurst Inlet project, now led by Sabina Gold and Silver Corp., (Glencore Corp. is another proponent) has seen the construction of a port facility and tank farm at Bathurst Inlet (Nunatsiaq News, 6 Sept. 2018; nunatsiaq.com). This infrastructure will enhance logistics for Sabina's Back River project in Nunavut. The government of Nunavut with the Kitikmeot Inuit Association is also proposing a largely federally-funded road from Grays Bay on Coronation Gulf to the NWT border near Lupin. This route is similar to the stalled MMG project, and it seems some partnership may be developed.

The Slave Geological Province Corridor (SGPC) arose from the 2013 GNWT Mineral Development Strategy (GNWT, 2013), which had a stated goal of investment in infrastructure and energy development in the NWT to improve access to mineral potential. A follow-up implementation plan (GNWT, 2014) recommended that the GNWT undertake a resource access corridor study; the Gal and Martin (2015) study was a part of that work.

A recent GNWT document ("Connecting to Opportunities: Slave Geological Province Corridor") promotes the SGPC as as an important transportation, hydro, and communications corridor, while connecting the mineral deposits of the region to points south and ultimately to a deep-water port in Nunavut.

In 2018, GNWT through the Department of Infrastructure and the Northwest Territories Geological Survey (NTGS) applied for funding from Canadian Northern Economic Development Agency (CanNor) to update the 2015 study with a GIS Study of Mineral Potential and Least-Cost Routing for a Slave Road Corridor. The requested funding was granted (CanNor News Release dated 4 March 2019; https://www.canada.ca/en/northern-economic-development/news/2019/03/major-resource-development-boost-for-northwest-territories.html).

4.2 SCOPE

The project is a Geographic Information Systems (GIS) based analysis of data which lend themselves to spatial analysis; particularly bedrock geology and the location and character of known mineral occurrences. Both of these digital datasets are available from the GNWT.

An initial project scoping meeting held on 23 January 2019 focused on the following data sources and tasks:

- Incorporate the updated Stubley (in prep.) digital bedrock geology compilation
- Update of mineral dispositions
- Update mineral occurrences, focus on area south of Lockhart Lake
- Surficial geology mapping was discussed. However, it was ultimately not included in the mineral potential study, as surficial geology is generally not an important factor in mineral potential.
- Integration of airborne geophysics using the “footprint” of survey areas
- Integration of Industrial Minerals as a commodity group: which was considered in the evaluation of mineral occurrences
- Till geochemistry database was found to be unsuitable for inclusion into the mineral potential workflow, but the importance of geochemical surveys was noted as a potential future work area

Ultimately, bedrock geology, mineral tenures, mineral occurrences, geophysical survey coverage and type, dykes and faults were considered to be factors of importance in determining mineral potential in the SGP. Geophysical survey coverage and dyke rocks were not considered in the 2015 study.

The type and format of the available geochemical survey data was not conducive to its inclusion as a factor. Likewise, road-building materials (rock and aggregates) were originally envisioned to be of interest, however these fall outside the realm of mineral potential, the main focus of the study. Additionally, finer-scale bedrock outcrop maps would be necessary for this work, and these are not uniformly available throughout the SGP.

The study area for the project is the SGP. In order to keep to the budget and time constraints, only mineral occurrences south of Lockhart Lake, and only the more developed ones, were examined in any detail by the expert panel. In Figure 1, mineral potential is indicated outside of the Slave Province proper, however, this outlying area was not subjected to the same methodology as for the SGP. The rectangular outline was only retained to minimize the edge effects of elements at or near the SGP boundary. Figure 3 shows the study area.

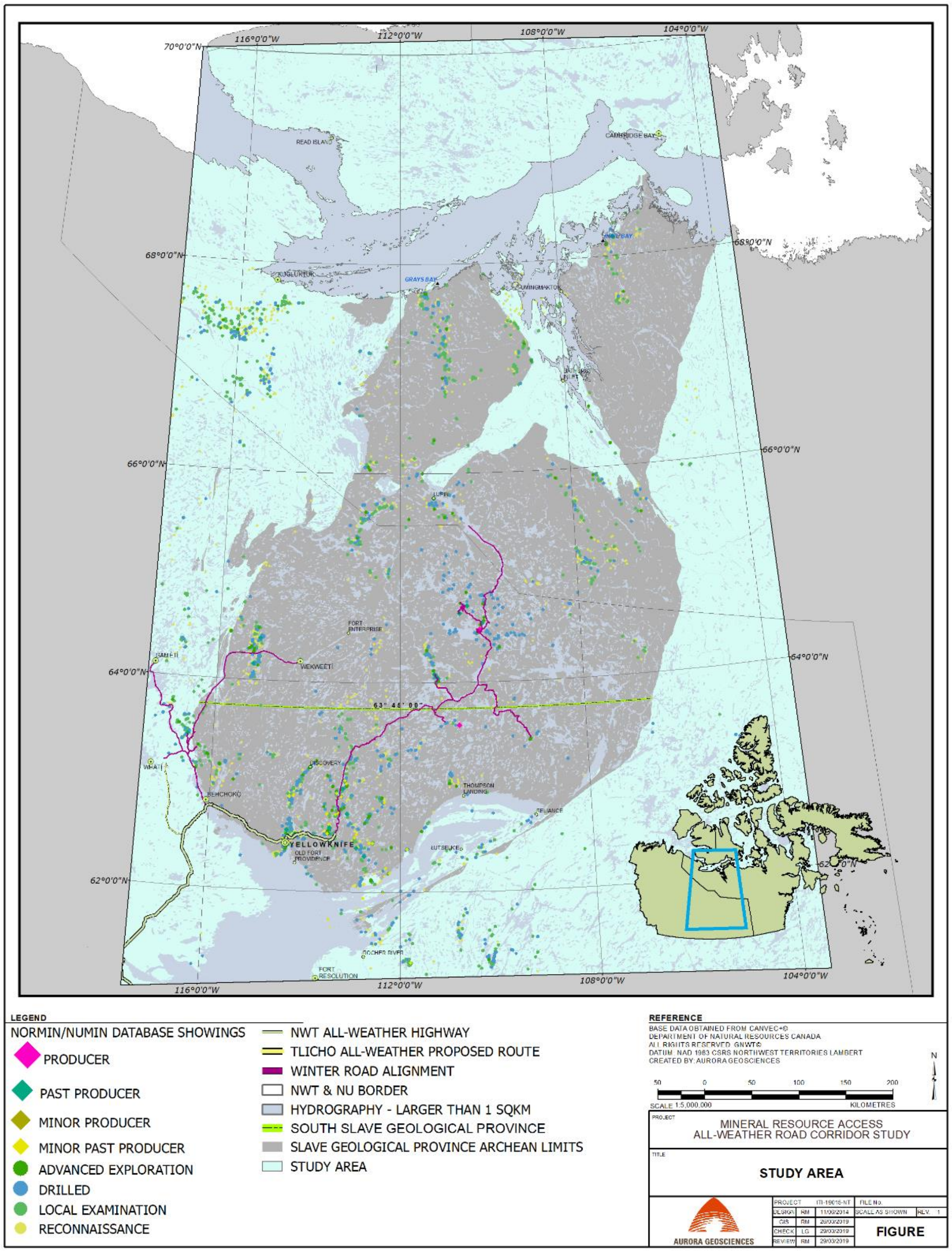

Figure 3 Project study area

The Slave Geological Province study area with mineral occurrences (from NORMIN/NUMIN databases). A line at 63°45' N indicates the north limit of mineral occurrences that were graded in this study. In addition, mineral occurrences southeast of Great Slave Lake were not considered. Note that on the thematic maps, areas outside the Slave Province are shown. This was done to reduce edge effects in the GIS analyses due to elements that were located at or near the edge of the Slave Province boundaries. The colour shading in the thematic maps should be discounted in these outlying areas.

5 METHODOLOGY

In keeping with the methodology of the 2015 study (Gal and Martin, 2015), this project involves four phases: refine methodology, compile the needed and available data, interpret the data, and report.

Six factors were chosen to characterize the mineral potential of the SGP: mineral occurrences, bedrock geology, mineral tenure, geophysical surveys, faults, and dykes. This is an increase of two from the factors used in the 2015 study. Geochemical surveys were considered early on but ultimately rejected, as discussed below.

Briefly, the methodology used was to determine variables for each factor, enlist a panel of experts to assign scores to the variables, and to collate, average and/or normalize the scores. Results from the 2015 study were included, where appropriate, by weighting the average scores of both studies.

Finally, the six factors were scored against one another, to determine the relative importance of each in estimating mineral potential.

The method generally follows the principles of analytical hierarchic process (AHP), which is further discussed below.

The Geographic Information Systems (GIS) treatment of the scoring results to produce maps is also reviewed below.

5.1 ANALYTICAL HIERARCHY PROCESS

The analytical hierarchic process (AHP; Saaty, 2008) is a common method to enable decisions where a wide variety of input factors, ranging from objective numbers to subjective judgements, are deemed to have some impact on an outcome. The basic method involves defining an objective (in this case, evaluate mineral potential), structure the elements (the six factors to be considered), perform pair-wise comparisons, calculate weighting ratios, evaluate (through GIS analysis), and obtain rankings (high versus low mineral potential). The strength of AHP is that variables that are fundamentally different, and differently characterized (objectively known values versus subjective opinions) can still be evaluated relative to one another. The method relies on subjective decisions to make pair-wise comparison, and these are converted to numerical values to enable computation. Because subjective decisions are required, it is better to have a larger number of informed experts pass judgement, rather than relying on one or a few people. Ideally the goal would be to attain a normal distribution of assigned scores for each variable.

To perform the pair-wise comparisons, a nine-level scale was used to judge the relative merits (preference or importance for mineral potential) of one variable over another. The nine levels comprised comparator terms, and a numerical score equivalent. Table 1 lists the comparator terms and numerical equivalents used in this study (after Nouri et al., 2013).

Table 1. Comparator Scale. Comparison scale used in our Analytical Hierarchy Process (AHP) to evaluate variables in a pair-wise manner (after Nouri et al., 2013).

General Comparator	Score
Equal	1
Slightly Better	2
Little Better	3
Moderately Better	4
Better	5
Quite a Bit Better	6
Much Better	7
Critically Better	8
Utterly Better	9

For example, if factor "A" is considered "much better" (or much more important) than factor "B" in indicating mineral potential, A was given a score of 7 versus B. B would be scored 1/7 versus A, and A would score 1 against itself, as per the example 2x2 matrix below (Table 2).

Table 2. Example 2x2 Matrix. *Example of a 2x2 pair-wise comparison matrix.*

Factor	A	B
A	1	7
B	1/7	1

In the current study, a panel of up to nine geoscientists made pair-wise comparisons for mineral tenure, certain aspects of mineral occurrences, and geophysical surveys. Additionally, pair-wise comparison was used to evaluate the six factors against one another. Each pair was evaluated using the nine-level comparator scale (Table 1). The paired values could be used to populate a matrix, from which a weighting percent were calculated by summing rows and normalizing. An example matrix is shown below (Table 3), illustrating four variables used to characterize a specific outcome or goal.

Table 3. Example 4x4 matrix *Example of a 4x4 pair-wise comparison matrix with summed rows and calculated weights.*

Variable	A	B	C	D	Sum of Row (fractions converted to decimals)	Normalized, rounded % (weighting)
A	1	5	7	8	21.00	56%
B	1/5	1	4	6	11.20	30%
C	1/7	1/4	1	2	3.39	9%
D	1/8	1/6	1/2	1	1.79	5%
Sum					37.38	100%

In the example in Table 3, variable A would account for 56% of the value toward determining the outcome, while variable D is judged less important and contributes only 5%. An advantage of the AHP over simply assigning weights is that it encourages the evaluators to critically judge each variable individually against all others, rather than simply judge a variable against the single criteria of the total weight available (i.e., 100%).

5.2 SIMPLE SCORING

For bedrock geology units, and the Development Stage of mineral occurrences, a simple scoring scheme (0.1-9.9 or 0.1-99.9) was used by the panelists; partly because the large number of individual bedrock types and mineral occurrences would have resulted in a cumbersome and time-consuming number of pairs to evaluate. Scores were averaged, weighted with 2015 data where appropriate.

Because of the greater amount of information attached to mineral occurrences in the database, both the primary mineral commodities and level of any available resource estimate were considered in addition to the Development Stage of the occurrence. These were, respectively, scored numerically and by pair-wise comparisons. The Development Stage, Commodity and Resource/Reserve variables were then themselves compared in pair-wise fashion to obtain a weighting for each variable, to more fully characterize each mineral occurrence.

Dykes and faults were treated as “yes/no” propositions, meaning they were either present or not. Therefore they did not need to be evaluated by an expert panel. However, future work could involve more detailed evaluation of these factors. The special case of the Malley group of dykes is discussed below.

5.3 INCLUSION OF 2015 WORK

As mentioned above, the subjective nature of pair-wise evaluations and scoring of variables is improved by a greater number of evaluations, with the goal of moving toward a normal distribution in scores for any given variable. In order not to lose the 2015 work, these results were retained where appropriate and averaged by weighting against the current study results. Where the same evaluators contributed to both 2015 and 2019 studies, only the most recent results were used, to avoid overweighting with respect to individual evaluators.

5.4 GIS ANALYSIS

The GIS analysis involved the division of the study area into cells in map space, measuring 100 m by 100 m. Each cell holds some numerical score for each of the six factors based on AHP methods or simple scores. These scores were standardized to cover a range from 0-255, to allow for a colour-graduated display in the GIS. The result was a series of heat maps for the variables.

Whereas the actual study area is the SGP proper, a rectangular area larger than the SGP was employed in GIS, to account for edge effects at or near the SGP boundary. While displayed in maps and figures, areas outside the SGP should not be regarded as having been considered in this project.

Specific GIS workflow treatment of each factor is reviewed below.

5.4.1 Faults

The fault dataset from Stubley (in prep.) consists of polyline features. As the GIS analysis required all cells in the study area to contain a value in order to create a suitability grid, an exponential function was used to create a raster with cells consisting of values that fell away relatively rapidly from a fault zone. This distance function converted the vector polyline data into a raster format.

The exponential function is recognized as an oversimplification, as it treats all mapped faults equally, without regard for width, length or age of fault zones, nor types of faults. Future work would benefit from subdividing faults by type, age or size, and developing some sort of scoring for these variables.

5.4.2 Dykes

The dyke dataset from Stubley (in prep.) consists of polyline features. These are dominantly Proterozoic dykes that have been subdivided into 27 sets based on age and general orientation. The lithology (diabase, or mafic gabbro / basaltic chemistry) is fairly consistent.

All dykes were considered equal, and an exponential function was used to create a raster with cells consisting of values that fell away relatively rapidly from the dykes. The exception to this was the Malley group of dykes, which are considered metallogenically distinct and possibly favourable for certain types of mineral deposits (e.g., Pietrzak, 2003). Polylines identified as belonging to the Malley group were upgraded in the bedrock geology layer, by increasing the score of the host bedrock unit polygon by 10 points, within map cells where the dyke occurred (see below and Figure 4).

Some dykes were large enough, or in a subhorizontal orientation (i.e., sills) such that they were mapped as polygon features in Stubley (in prep.). These were then treated as bedrock geology units (see below). None of the aforementioned Malley dykes were represented as polygons, and overall, the diabase dykes scored fairly low as bedrock units.

5.4.3 Mineral Tenures

The mineral tenures consist of polygon features. A pair-wise comparison was used to rank the tenure types and assign a score for each type. Since tenures do not fill the entire study area, a Euclidean Distance function was used to create a raster map where cell scores fell away with distance from a tenure.

5.4.4 Geophysical Surveys

Similar to mineral tenures, geophysical surveys were considered as polygon features, essentially areal “footprints” associated with the survey data. A pair-wise comparison was used to rank the survey types and assign a score for each type. Surveys do not fill the entire study area, so areas not covered by a geophysical survey were assigned a score of 1. This resulted in an abrupt edge to the mapped survey areas, in contrast to a Euclidean Distance function, as used for Mineral Tenures.

5.4.5 Geochemical Surveys

Geochemical Surveys were considered for inclusion as a factor contributing to estimated mineral potential, however the available data were not in a format that could be readily incorporated, given the time and budget constraints for this project.

However, in a pair-wise comparison of factors, geochemical surveys actually scored third in importance, behind mineral occurrences and bedrock geology, and just ahead of geophysical surveys. This underscores the perceived importance of these data, and future work could include enhancements to the geochemistry database to facilitate its inclusion as a factor.

On the other hand, it could be argued that geochemical surveys are already captured within the Development Stage variable of any associated Mineral Occurrence. But this only includes surveys that are directly associated with mineralization.

5.4.6 Bedrock Geology

Bedrock geology data consist of polygon features which do fill the entire study area. That is, there is no cell within the study area that does not correspond to a bedrock type. In this case, the scored bedrock polygons (vector data) were normalized and converted directly to a raster format.

As noted above, a buffer around Malley dykes (represented as polylines) was created and given an increased score. This was done by increasing the host bedrock unit polygon score by 10 points within the 100 m by 100 m cell through which the dyke polyline trace passed.

5.4.6.1 Kimberlites

Kimberlites were included in Stubley (in prep.) as point data, and the number of identified kimberlites was larger than that captured in the NORMIN/NUMIN mineral occurrence databases. Kimberlites were evaluated as a separate bedrock unit as well, and unsurprisingly they scored high. In order to capture the positive nature of discovered kimberlites that were not included in the mineral occurrences, the kimberlite point data were converted to a 400 m diameter circle (essentially, a four cell block in GIS map space) and the bedrock geology score was assigned to these cells.

5.4.7 Mineral Occurrences

The mineral occurrences are point data. Scores were given to mineral occurrences based on a relative weighting of their Development Stage, Primary Commodity and Resource/Reserve estimate. An inverse distance weighting function (IDW) was used to interpolate values between the mineral occurrences. IDW interpolation determines cell values using a linearly weighted combination of a set of sample points. The weight is a function of the inverse distance.

The IDW resulted in a zone of influence around each point. This zone of influence has a basis in geological reality because: a) each mineral occurrence has some associated area of exploration and development; b) there is some error attached to most of the locations (in many cases +/- 500 m, particularly for the Reconnaissance and Local Examination level occurrences); and c) it is reasonable to assume some physical attribute of the occurrence, such as alteration, that can be described as a surrounding zone of influence around an occurrence.

One negative aspect of IDW is that for many closely spaced occurrences, the distance between occurrences is small, and the corresponding small zones of influence appear to degrade the importance of the area. This is in contrast to an isolated major mineral occurrence, where because the distance to nearest neighbours is large, the zone of influence ascribed to the occurrence is large in map space, and may overstate its importance.

5.5 Mineral Potential Map

An AHP pair-wise comparison of the six factors resulted in their relative weightings, which were applied to a summation of the individual factor cell scores to obtain aggregate cell score, to create the resultant suitability raster, or mineral potential heat-map. The heat map is a raster figure with standardized values in a range from 0 – 255, displayed with a "blue to red" colour scale. The map is based on a 100 m by 100 m cell size, to balance out required resolution and computational time and power with the limitations of the input data with respect to physical location uncertainties.

5.6 "LEAST-COST" ROAD PATHWAY

To create the optimized road path map, the mineral potential data (the "suitability grid") was inverted, resulting in a "cost-surface" raster. This cost-surface raster was used in conjunction with the current NWT all-weather highway system, to create a "cost-distance" raster. The cost-distance raster identifies, for each cell, the least accumulative cost distance to the highway system. The cost-distance values represent the interpreted accumulative "cost" with respect to the distance from the source, where higher values are of lower mineral potential and lower values are of higher mineral potential, and the values accumulate with distance away from the highway. As such, by selecting a destination (Lockhart Lake) it is possible to determine the "least-cost pathway" from the NWT all-weather highway system; meaning the pathway which travels through the areas of highest interpreted mineral potential while minimizing distance.

In creating the optimal path, exclusionary zones of hydrography (waterbodies greater than 1 km^2) and wetlands (saturated soils from CANVEC data) were used, as constraints, to restrict the route.

The GIS workflow, showing input by the geoscientists and the resulting maps, is shown in simplified fashion in Figure 5.

There are of course many additional factors which need to be considered in road routing, among them: wildlife and protected areas, fee simple and other land titles and land withdrawals and restrictions, surficial geology, hydrography and wetlands; which have little or no bearing on mineral potential. However, they do have influence on mineral exploration as well as road routing. In fact, bedrock geology outcrop maps, while outside the scope of this study, have a strong influence on road routing as well, as these may well serve as quarry sites for road-building materials.

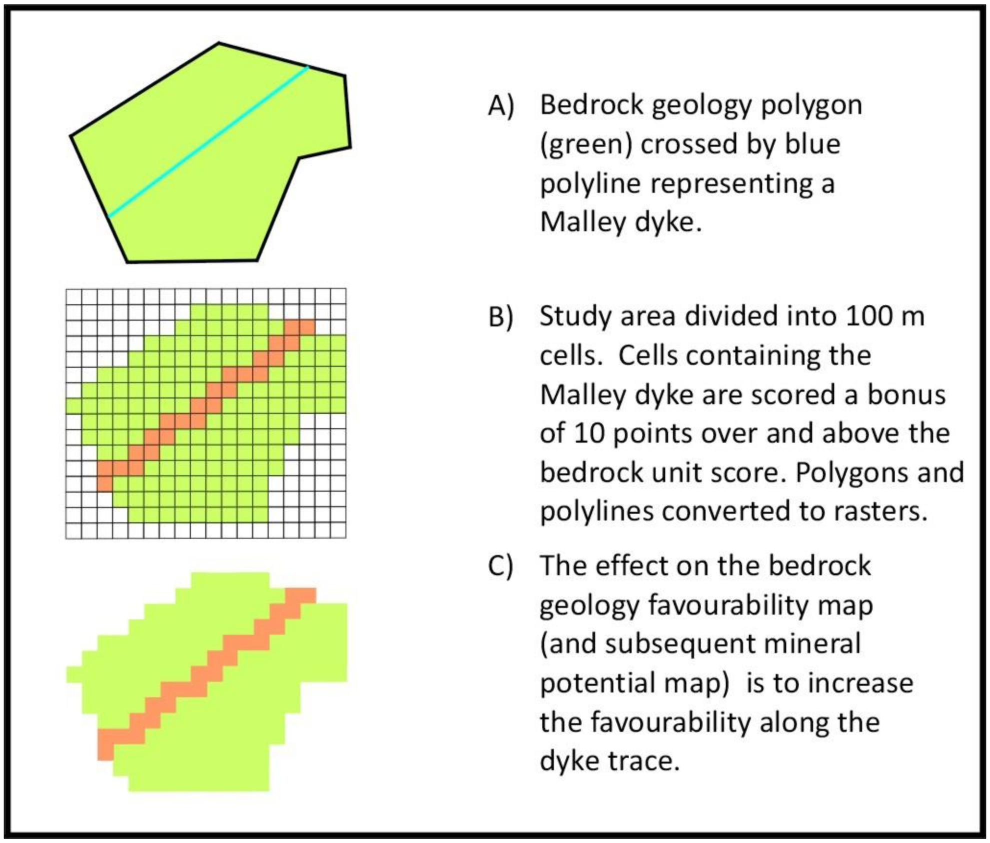

Figure 4. Malley dyke polyline treatment. *Schematic model to account for enhanced mineral potential in Malley type dykes, where the dykes are represented as polylines overlying bedrock geology polygons in GIS*

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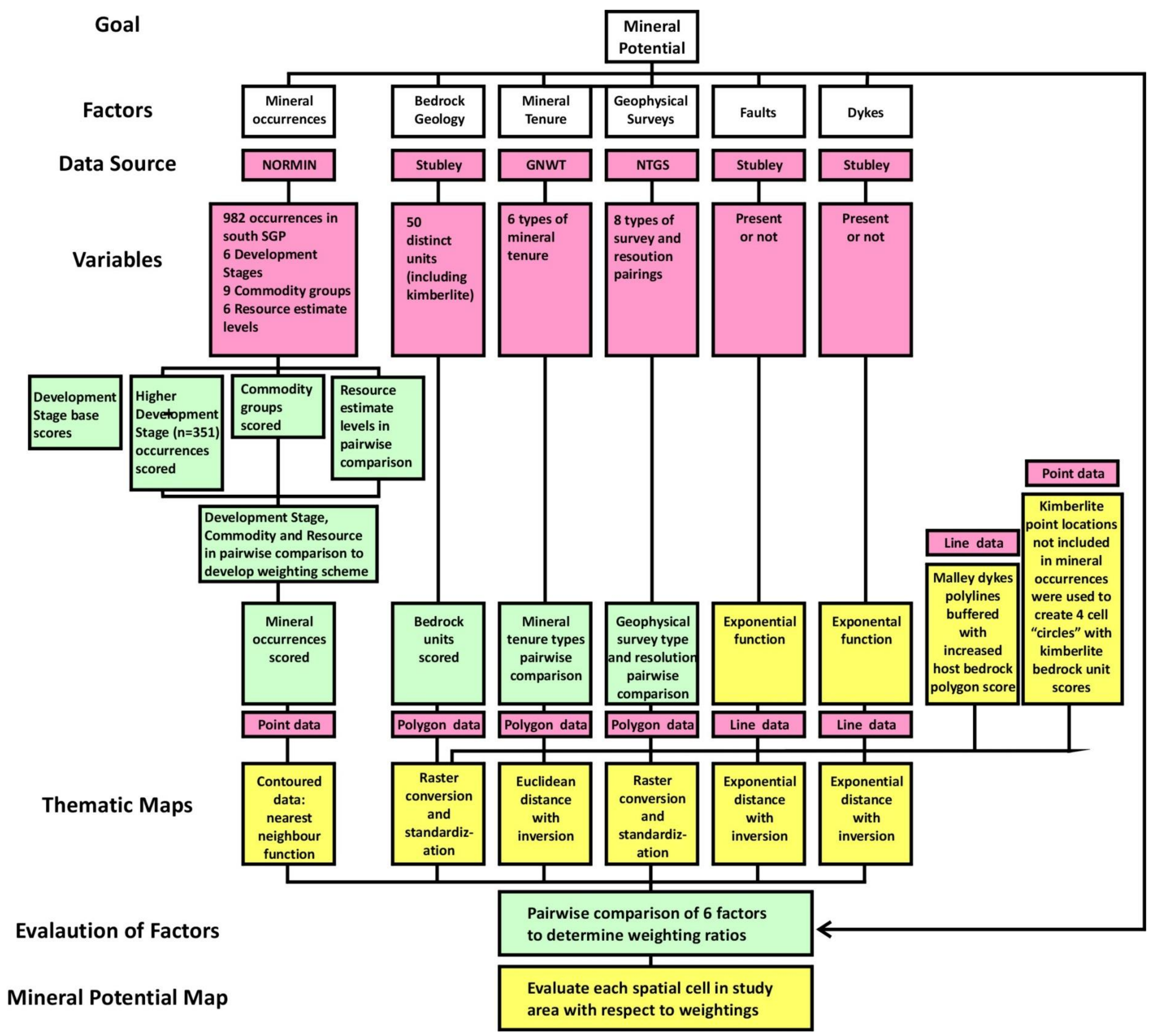

Figure 5. Simplified Workflow. *Simplified workflow for GIS mapping project. The largely subjective input points from geoscientists are shown in green. GIS processes are shown in yellow. A more detailed version is in Appendix I.*

6 DATA COMPILATION

The data are available in the public domain and distributed by GNWT sources, in particular through the Northwest Territories Geological Survey (NTGS). The existing databases were used as constructed to select variables to be evaluated, without changing the database structure. This allows for future expansion and or refinement by other parties, using a public data set and transparent workflow.

The bedrock geological data (bedrock geology, faults, dykes, kimberlites) are part of an open file report in the process of publication (Stubley, in prep.), and were released by NTGS to Aurora for use in this study.

Table 4 below summarized data sources.

Table 4. Sources of Data

Dataset and Variable	Sources
NORMIN-NUMIN showings: Known mineral occurrences, development stage, commodity	GNWT NTGS Canada-Nunavut Geoscience Office Company websites, technical reports, news releases
Mineral deposit reserves and resources	Company websites, technical reports, news releases GNWT NTGS Canada-Nunavut Geoscience Office
Bedrock Geology, faults, dykes, kimberlites	Stubley (in prep.) – SGP compilation
Mineral Tenure: mining leases, claims, prospecting permits (current and lapsed), protected areas or reserves	GNWT Centre for Geomatics (geomatics.gov.nt.ca) Nunavut data from open.canada.ca/data
Geophysical Survey data	GNWT NTGS Open Report 2018-001 (Mirza and Fischer, 2018)
Surficial Geology: surface geology units, eskers, wetlands	Government of Canada – CANVEC Series

As noted in the table above, the mineral occurrence data within the study area were obtained from the NWT mineral showings database (formerly "NORMIN"; http://webapps.nwtgeoscience.ca/WebAppsBeta/Searching/ShowingsSearch.aspx), and the NUMIN database maintained by the Canada-Nunavut Geoscience Office (http://nunavutgeoscience.ca/pages/en/numin.html). We refer to the NWT database here as "NORMIN" for simplicity.

7 EVALUATION OF THE DATA SETS (FACTORS)

Thematic maps were created through the evaluation of each factor according to some scoring scheme. Evaluations of the individual datasets were completed by a panel of knowledgeable geoscientists. From six to nine panel members completed worksheets to rank and score the variables according to the scoring scheme. In order to utilize previous evaluations (Gal and Martin, 2015), a weighted average was used where appropriate to arrive at a final score. Panel members that contributed to both studies were excluded from the 2015 results, in order to not grant double weighting to some evaluators.

The criteria considered for each factor dataset are outlined in Table 5 below:

Table 5. Criteria Evaluation Variables. Variables considered in evaluating mineral potential, and the criteria and sub-criteria that characterize each. *kimberlite was added as a bedrock unit. **note special case of Malley dykes as discussed in text.

Factor	Variable	Number of Sub-variables
Bedrock Geology	Lithological Unit (from map Legend)	50*
Mineral Tenure	Tenure Type	6
Faults	Presence or Absence	2
Mineral Occurrences	Development Stage	7 Development Stages
	Resource-Reserve	6 Resource Estimate Levels
	Commodity	10 Commodity Classes
Dykes**	Presence or Absence	2
Geophysical Survey	Survey Type and Survey Resolution	8
Geochemical Survey	not evaluated	n/a

7.1 FAULTS

Faults were obtained from the digital map of Stubley (in prep.). Faults are considered favourable, as while not necessarily host themselves to mineral deposits (although they can be both for brittle displacement veins and ductile shear zones), they may be the conduits for mineralizing fluids (and as such they are proximal features). Also, they are often associated with minor structures that occur within an enveloping zone, and there can be a demonstrable relationship between distance from a fault and intensity of alteration, veining, etc.

As mentioned above, different fault types were not considered separately, also this could potentially be done in future work. Fault lines were evaluated with an exponential scaling equation that decreased the score rapidly away from a high of 255 on the line. Figure 6 shows the Fault factor as a thematic heat map for the SGP. The faults are widely distributed throughout SGP, with north and northeast trends common in the southern part of the study area.

7.2 DYKES

Mafic dyke swarms occur throughout the Slave Province, and Stubley (in prep.) lists 18 unique named dyke swarms, along with nine other undifferentiated groups. These groups of parallel dykes are a good indicator of crustal stress regimes and can be related to fault zones. In Stubley (in prep.) these have been indicated as polylines in the GIS, as most are too narrow to be mapped as polygons at the map scale. Dykes range in width from a few metres to hundreds of metres. In a few instances, dykes (morphologically sill-like) are large enough to be mapped as polygons, and were scored as a bedrock geology unit.

As a bedrock unit, Proterozoic mafic dykes were ranked low by panelists. There are of course exceptions, such as ultramafic dykes and sills. Another possible exception is the Malley dyke swarm. The Malley dykes (Frith, 1982) are a NE-trending set, dated at 2231 +/- 2 Ma (U-Pb, Buchan et al., 2012). Geochemical studies by Pietrzak (2003) suggest they may be prospective for V or Ti mineralization or other deposits commonly associated with mafic-ultramafic intrusive complexes. It should also be mentioned that the diabase rock comprising many Proterozoic SGP dykes can furnish good road building material.

Figure 7 shows the Dyke factor as a thematic heat map for the SGP. They are distributed throughout the SGP, with northwest trends being dominant.

7.3 MINERAL TENURE

Mineral tenure data was gathered from the GNWT for the Northwest Territories (Centre for Geomatics, http://www.geomatics.gov.nt.ca/); and for Nunavut from the Government of Canada (open.canada.ca).

Existing mineral tenure is generally a positive indicator of mineral potential, as it indicates that other explorers have found the area to be of interest. Leases are an advanced stage of mineral tenure, indicative of a deposit that has been found, and that plans have been made to exploit it. A lease would of course be characterized by an advanced Development Stage mineral occurrence. Claims are an earlier stage of mineral tenure, and generally indicate ground of interest. Prospecting permits awarded as an incentive to explore less popular areas (where there are no pre-existing claims), and because they are so large, they are less indicative of geological favourability.

Lapsed, or expired mineral tenures, are generally less favourable for mineral prospectivity, although there are many possible reasons why tenure would expire apart from failure in exploration. Expired leases are a special case, because in order for a lease to have been originally awarded, there had to be the expectation of production, and therefore they represent a strong exploration target. Most lapsed leases are associated with past producing mineral occurrences. Lapsed claims cover almost all of the SGP, and are thus of limited help in discriminating the mineral potential of the study area.

Eight panelists evaluated the six types of mineral tenure through a pair-wise comparison. The scoring results were averaged, and weighted against the values from Gal and Martin (2015), in which three panelists evaluated the pairs. Table 6 lists the weighted scores expressed as a percentage value.

Table 6. Mineral Tenure scores expressed as percentage weighting

Mineral Tenure Variable	Weighted Score (%)
Active Mineral Leases	35.20%
Active Mineral Claims	23.58%
Active Prospecting Permits	10.17%
Past Mineral Leases	18.88%
Past Mineral Claims	9.75%
Past Prospecting Permits	2.43%

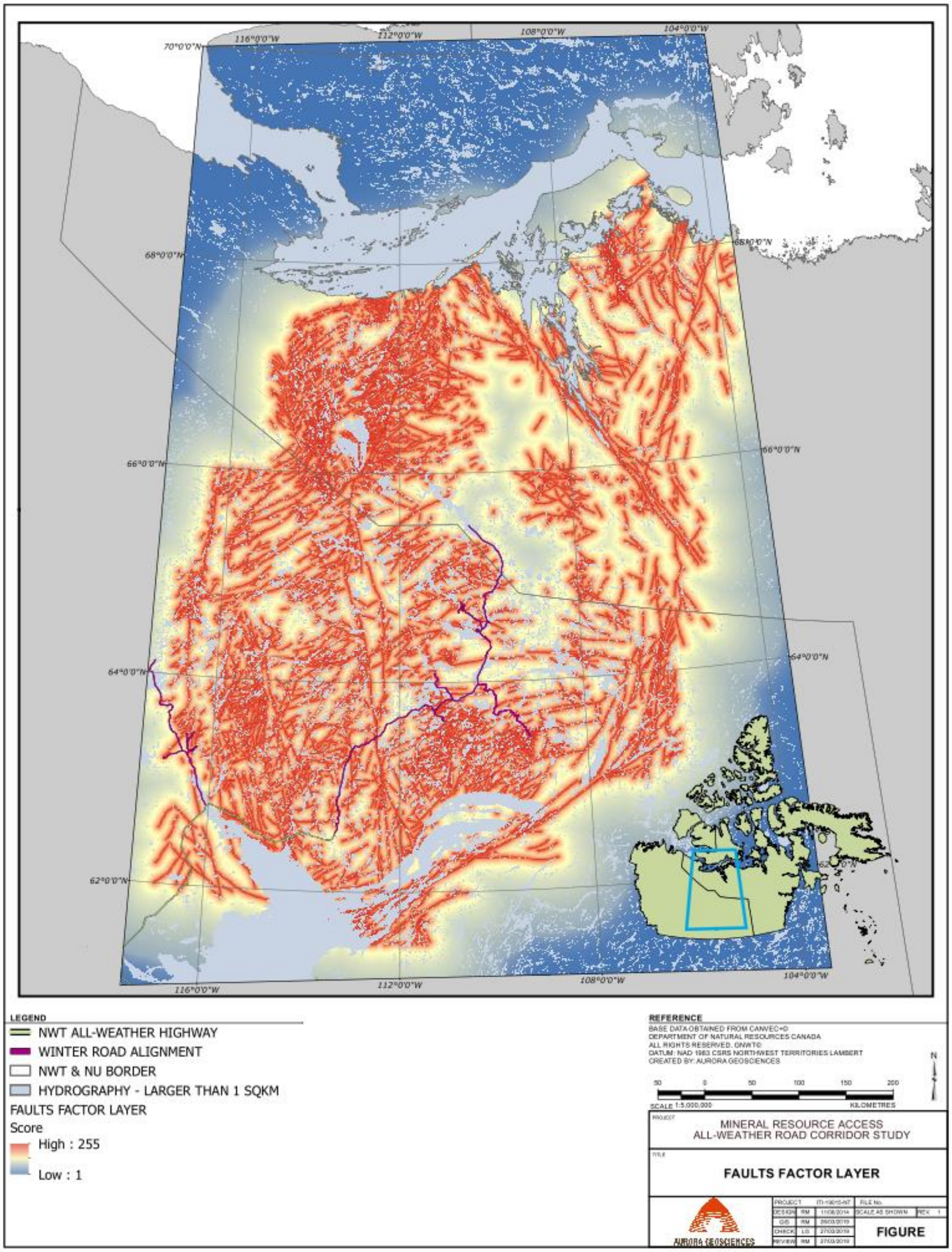

Figure 6 Fault thematic heat map

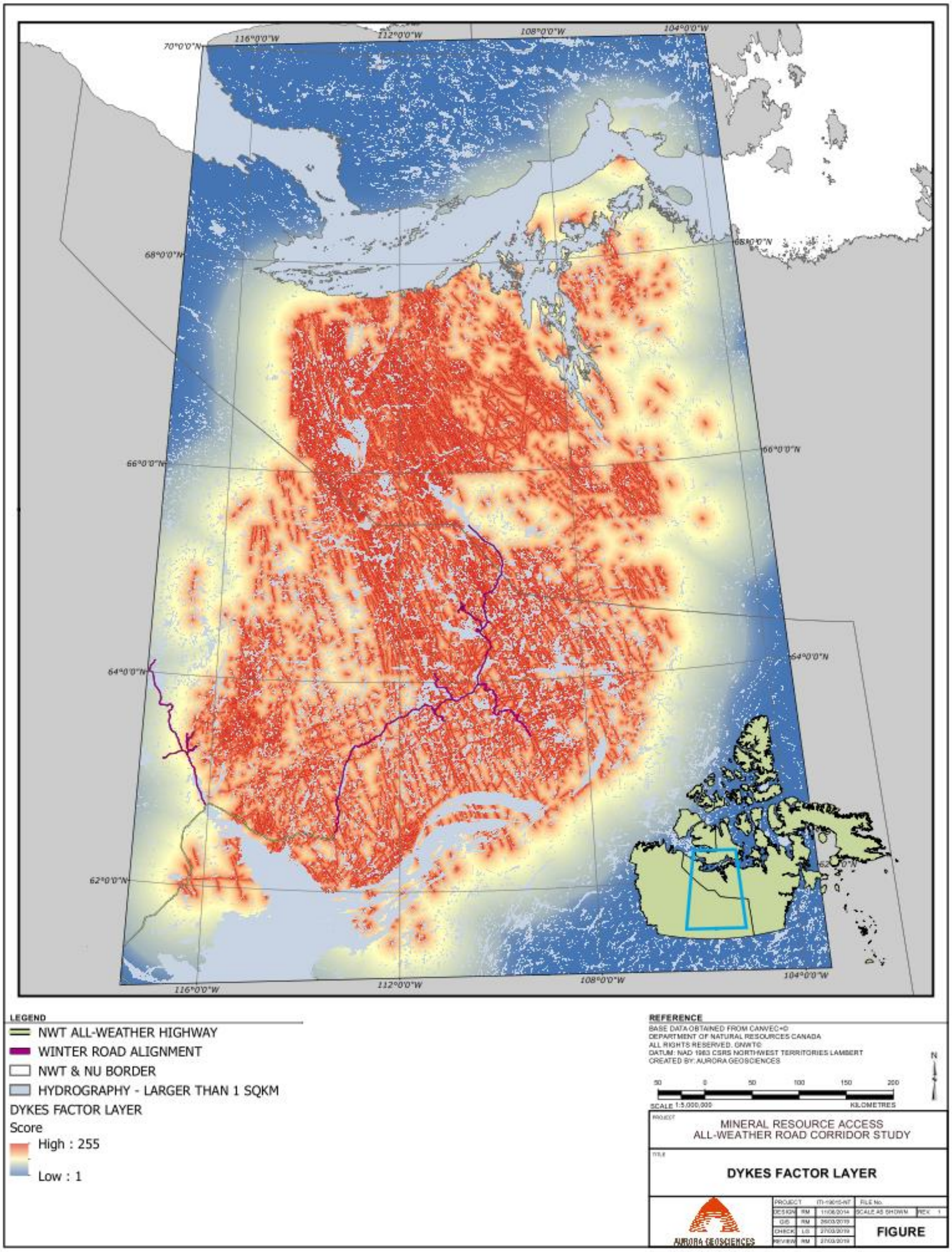

Figure 7. Dykes thematic heat map

Leases, claims, and expired leases were considered the most important tenure types, while lapsed prospecting permits were rated low. This is the same generally as the 2015 study results.

Figure 8 shows the Mineral Tenure thematic map. In the southern SGP, the heat map shows concentrations of activity around the Lac de Gras / Gacho Kue area as well as along the Yellowknife Greenstone Belt.

For consistency with the 2015 study, a Euclidean Distance function was used to describe the reduced influence with distance from a tenure boundary. Using a “sharp” boundary for the tenures, where the area outside a tenure was given a score of 1, did not alter the final mineral potential or route maps. It is debateable as to which method is preferable in a mineral potential context. Certainly in mineral exploration there is the appeal of exploring ground near to other claims where a discovery has been made.

7.4 Geophysical Surveys

Geophysical survey data was obtained from NTGS Open Report 2018-001 (Mirza and Fischer, 2018), and is only for surveys that were wholly or partly performed within the NWT. The existence of geophysical surveys is a generally positive aspect in indicating mineral potential, as it indicates interest similar to Mineral Tenures. A wide variety of surveys might be carried out over various scales; from regional airborne surveys over tracts of land well beyond any tenured lands, to tightly focused ground surveys over known mineralized showings.

From the existing database, survey types were distilled into four basic methods (electromagnetic, gravity, radiometric, magnetic) at two scales of resolution (grid lines spaced less than and equal to 400 m, or greater than 400 m).

This resulted in eight variables which were evaluated against one another by pair-wise comparison, by a panel of eight geoscientists. Results are expressed as a percentage weighting in Table 7.

Table 7. Geophysical Survey Pair-wise Comparison. *Pair-wise comparison of mineral tenure types, expressed as weighted average percentage values*

Geophysical Survey Variable	Weighted Score (%)
Electromagnetic Survey – 0-400 m line spacing	25.21%
Magnetic Survey – 0-400 m line spacing	21.89%
Electromagnetic Survey –400 m + line spacing	15.14%
Magnetic Survey –400 m + line spacing	12.87%
Gravity Survey – 0-400 m line spacing	9.83%
Radiometric Survey – 0-400 m line spacing	7.13%
Gravity Survey –400 m + line spacing	4.77%
Radiometric Survey –400 m + line spacing	3.16%

Electromagnetic and magnetic surveys were considered the most important indicators of mineral potential. Gravity and radiometric surveys were judged of lesser importance. Unsurprisingly, more focused surveys with line spacing of 400 m or less were judged more favourably.

It is recognized that both the groupings of survey types, and the survey resolutions, are extreme simplifications, and that there are many variables within geophysical surveys which have a bearing on perceived mineral potential which were not explored here. However, it is thought that some value was still derived from this existing database, and the results helped this analysis. Future work could focus on retooling the database to further differentiate scales and types of surveys.

Figure 9 is the thematic heat map for geophysical surveys. Survey footprint boundaries were treated as sharp, with values of 1 assigned to ground outside the survey blocks. This resulted in sharp boundaries to the survey polygons. A Euclidean Distance function could have been used, as with Mineral Tenures. The heat map shows that in the NWT portion of the SGP, the survey activity was heavily skewed toward the east side of the SGP. This is due to the concentration of diamond exploration programs in the area over the last 25 plus years.

7.5 GEOCHEMICAL SURVEYS

Initially it was thought geochemical surveys could be incorporated into the work. It was envisioned that the footprint areas of such surveys could be evaluated, with respect to the type (sample material, analytical procedure) and resolution (sample density) of these surveys, through a pair-wise analysis by expert panelists to determine which kind of surveys were deemed most reflective of mineral potential. Unfortunately, the data set from NTGS was only as point data and was fairly incomplete. There was insufficient time and budget to build “footprints” for survey areas, and to incorporate data that was not already in the Kimberlite Indicator and Diamond (KIDD) and Kimberlite Indicator Mineral Chemistry (KIMC) databases of the NTGS.

However, panelists were asked to rate geochemical surveys by pair-wise comparisons with the six main factors. When all seven factors were considered, Geochemistry surveys were ranked the third highest in importance as an indicator of mineral potential (slightly ahead of geophysical surveys). Therefore, should this work continue and expand, it would be worthwhile to somehow consider and incorporate geochemical surveys. One further step might be to identify anomalies from the data (90th percentile results, for example), and rate the importance of these point data anomalies, and thus incorporate them similar to the treatment of point data mineral occurrences.

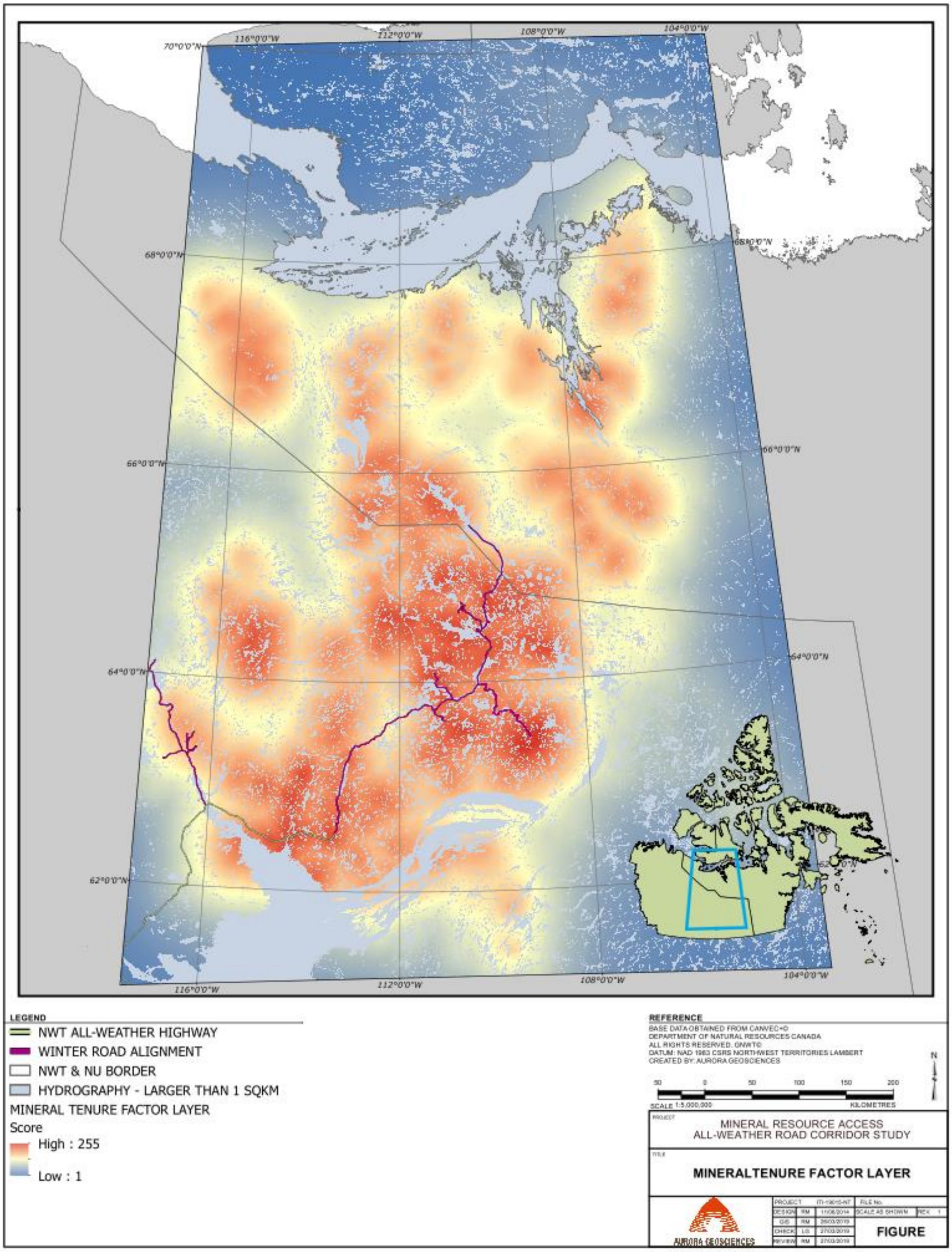

Figure 8. Mineral Tenure thematic heat map

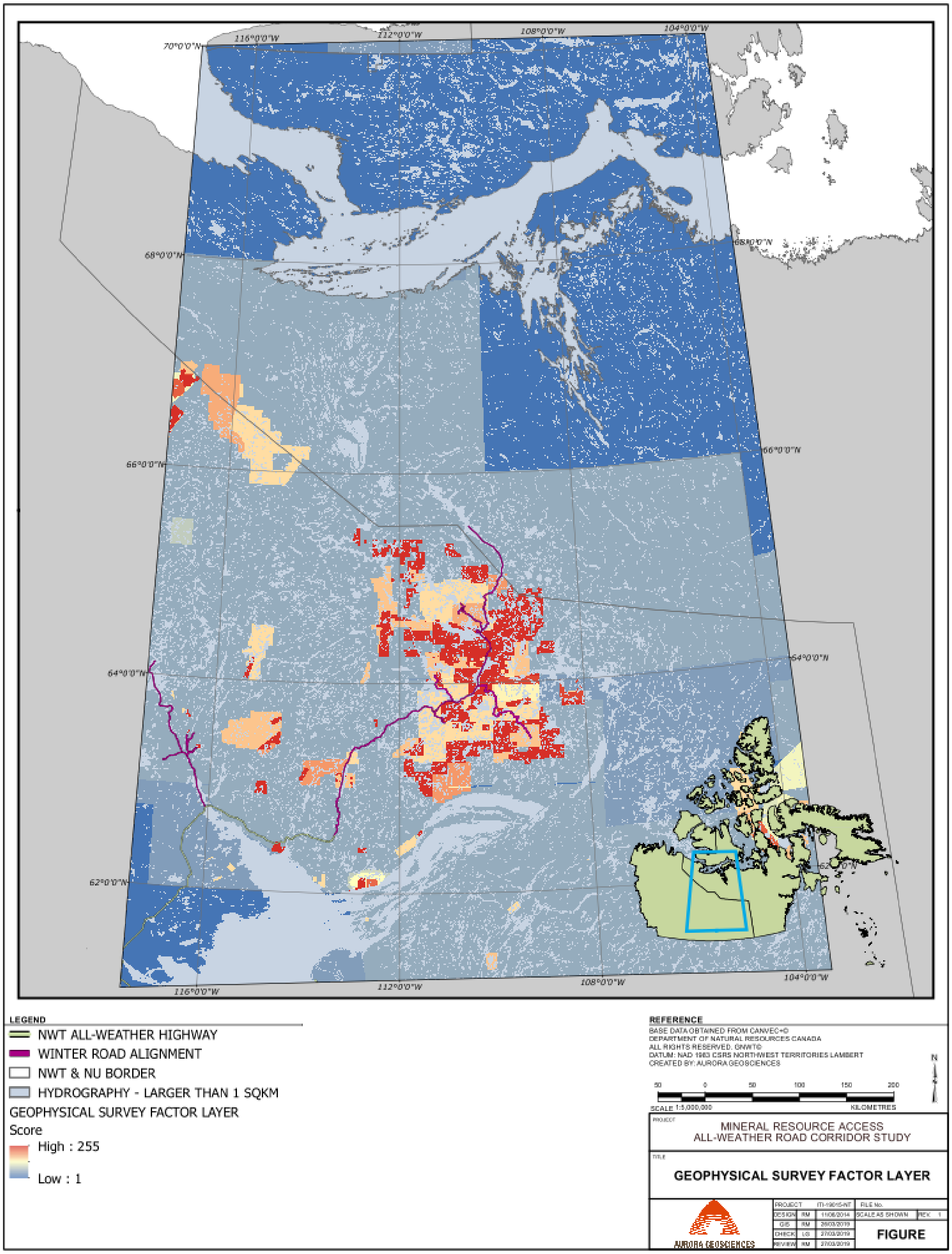

Figure 9. Geophysical survey thematic heat map

7.6 BEDROCK GEOLOGY

The bedrock geology dataset (Stubley, in prep.) was evaluated using the bedrock units listed in the legend. Forty-nine bedrock units were considered; kimberlites were added as a separate bedrock type to be scored (see below).

Eight panel members were asked to score bedrock units from 0.1 to 99.9, with 99.9 being the most favourable, considering which bedrock types were generally more prospective for hosting mineral deposits, or more generally, indicative of mineral potential.

The number of mineral occurrences per unit area of outcrop for each bedrock type (essentially the mineral occurrence density) was provided to the panelists, as an illustration of a potential objective factor in determining favourability. The order of bedrock units presented in the worksheet was generally in the order of preference from the 2015 study.

The average score was calculated and weighted against the Gal and Martin (2015) results, where three (different) geoscientists scored the bedrock units. Three new units are listed in Stubley (in prep.) that were not included in Stubley (2005), which served as the basis for the 2015 study. These three new units were scored by the first author in addition to the eight panelists. Table 8 lists the bedrock units and weighted average scores. The full lithological descriptions of the units are listed with scores in Appendix I.

Kimberlite was scored the highest of the rock units. Volcanic rocks, which comprised only five units in the Stubley (in prep.) legend, had four of the next five highest rankings after kimberlite. Therefore, it can be said with some confidence that volcanic rocks (i.e., greenstones) are considered indicative, or at least permissive, of higher mineral potential. This is the same finding as in Gal and Martin (2015).

It was expected that this factor would lead to the widest range of scores, and this is illustrated in Table 9 for two randomly selected geological units. There is much subjectivity in this type of scoring, as it is based largely on panel member's experiences and perceptions. However, as noted in Gal and Martin (2015), the relatively low rating of the granitoid rocks is perhaps unfair, and more a function of the relatively low amount of exploration these rocks have received to date.

Table 8. Bedrock units and scores. The units and Legend codes are from Stubley (in prep.; his map attribute "Legend Code")

Legend Code	Weighted Average Score	Rock type
k	91.29	kimberlite
Avf	81.54	Volcanic rock
Avm	79.92	Volcanic rock
Avx	77.46	Volcanic rock
Ab	74.26	Mixed types
Avc	70.81	Volcanic rock
Ac	67.63	Intrusive rock
Atm	66.01	Sedimentary Rock
Pm	63.64	Intrusive rock
Am	60.10	Intrusive rock
Ams	57.37	Intrusive rock
Pa	56.09	Intrusive Rock
Aam	53.72	Sedimentary Rock
Aal	53.19	Sedimentary Rock
Ppx	52.63	Intrusive rock
Atl	52.46	Sedimentary Rock
As	49.18	Sedimentary Rock
Pv	45.55	Volcanic Rock
Agkm	43.36	Intrusive Rock
Agk	42.91	Intrusive Rock
Acg	41.54	Sedimentary Rock
PAa	40.73	Intrusive Rock
Ags	38.63	Intrusive Rock
Ath	38.54	Sedimentary Rock
Agb	35.37	Intrusive Rock
PAgt	35.22	Intrusive Rock
Atg	35.08	Sedimentary Rock
Po	34.81	Mixed types
Agbm	32.74	Intrusive Rock
Pgt	32.60	Intrusive Rock
Pu	30.92	Mixed types
Pg	30.91	Intrusive Rock
Psc	30.45	Sedimentary Rock
Pal	29.82	Sedimentary Rock
Pal	29.45	Sedimentary Rock
Psq	29.19	Sedimentary Rock
Agd	28.66	Intrusive Rock
Pt	28.28	Sedimentary Rock
Ag	27.63	Intrusive Rock
PAm	26.75	Intrusive Rock
Agnp	26.53	Mixed types
Agkx	26.19	Intrusive Rock
Agx	26.05	Intrusive Rock
PAt	22.75	Mixed types
Amp	22.50	Intrusive Rock
Ash	22.35	Mixed types
Agnb	15.89	Intrusive Rock
Agn	15.68	Intrusive Rock
PAg	14.53	Mixed types

Table 9. Spread of scores in bedrock units. Individual panelist scores for two randomly selected units. *Unit PPx was not included in Stubley (2005) on which Gal and Martin (2015) was based

Bedrock Geology Unit	Individual Panelist Scores	2019 Average	2019 Std. Dev.	2015 Average
PPx	12, 32, 50, 53, 58, 60, 77, 79	52.63	22.2	*n/a
Agx	1, 3, 10, 21, 30, 53, 60	25.43	23.6	27.7

7.6.1 Kimberlites

Kimberlite locations were obtained from the Stubley (in prep.) database. These are greater in number than in Stubley (2005) or in NORMIN-NUMIN entries.

Not surprisingly, kimberlites were judged very highly as a bedrock type by the panelists. Even though some have been demonstrated to be non-diamondiferous, they do tend to occur in clusters or belts, which may include bodies with widely variable diamond grades and valuations. Thus, the existence of an individual kimberlite body may help define a field, where new discoveries (or re-evaluations) might occur.

As noted above, kimberlites locations from Stubley (in prep.) not also included in the NORMIN/NUMIN databases were assigned an arbitrary but reasonable 400 m diameter about the location point, and scored separately (as kimberlite bedrock type) from the host bedrock polygon. While the 400 m diameter footprint is reasonable, it should be noted that there are now several examples of diamondiferous kimberlites in NWT that do not conform to a simple, sub-vertical pipe or “carrot” shape.

Figure 10 is the bedrock geology thematic heat map. The greenstone belts show up as distinct highs. This is similar to Gal and Martin (2015) results.

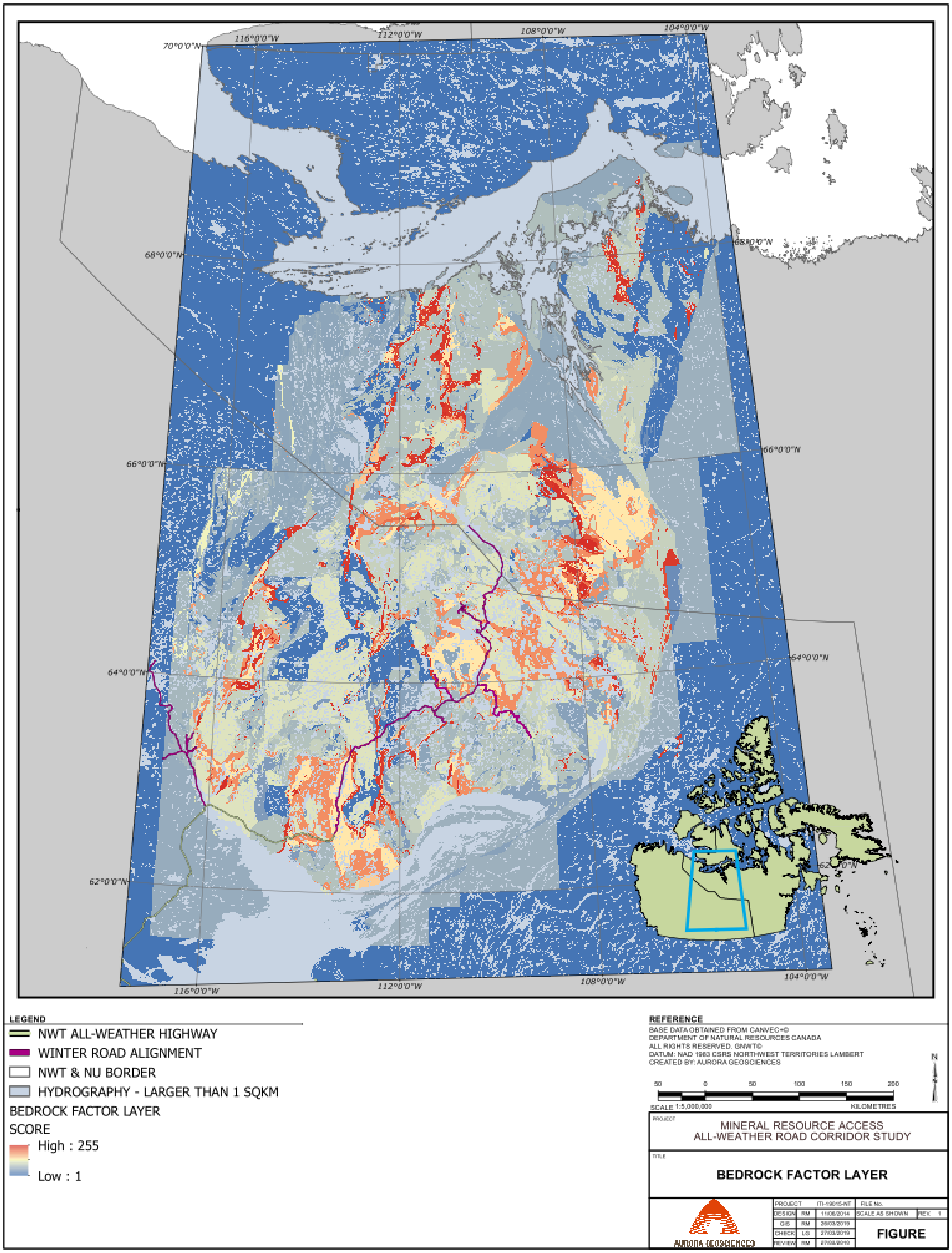

Figure 10. Bedrock geology thematic heat map.

7.7 MINERAL OCCURRENCES

The mineral occurrence variable was the most complex data set to deal with, principally because it includes many sub-variables which can affect the perceived mineral potential favourability. In general, most geoscientists would consider a favourable indicator of mineral potential in a region to be in the vicinity of a major deposit rather than minor occurrences, which in turn would be better than in an area with no known mineral occurrences. At the same time, a lack of exploration information does not necessarily indicate poor mineral potential.

For the current study, we focused on the area of the SGP south of Lockhart Lake (i.e., south of 63°45'N latitude). This area included 982 mineral occurrences. For the balance of the mineral occurrences in the SGP, we relied on the 2015 results.

Following standard AHP practices, we could have simply compared all Mineral Occurrences against one another in pair-wise fashion. However, with 982 unique mineral occurrences in the study area, that was unrealistic. Within the existing database structure, mineral occurrences are grouped by an attribute called "Development Stage", which is based on the amount and intensity of exploration and development works. This attribute, as well as database attributes "Commodity", and "Resources" lend themselves to evaluation that could be characterized by a numerical score. These three graded attributes are further discussed below.

The aim was not to characterize and grade an occurrence to reflect its own merit as a known or potential economic mineral deposit, but rather as an indicator of regional mineral potential.

7.7.1 Development Stage

Both NORMIN and NUMIN databases use the same terms and criteria for evaluating mineral occurrences based on the level of exploration, or Development Stage associated with each. The terms used range from "Reconnaissance" for the most poorly known and/or minor showings, through to "Producer" for active and operating mines (current as of the last database update). The criteria for each term are listed below. Table 10 lists the number of mineral occurrences in the southern SGP study area at each Development Stage. Two mineral occurrences that were unclassified with respect to Development Stage in the NORMIN database were assigned one upon review.

- **Producer:** a deposit which is currently being mined and producing a commodity.
- **Minor Producer:** a deposit which is currently being mined and producing a commodity, at rates of mining less than about 10,000 tonnes of ore per day.
- **Past Producer Abandoned, Past Producer Care and Maintenance, Past Producer Renewed Exploration**: a deposit which at one or more times was producing a commodity but is no longer. A Past Producer may be an abandoned mine, it may be on care and maintenance, or there may be renewed exploration for the same or different commodities in the vicinity. If a deposit cycles in and out of production over the years, its Development Stage in the database will be updated as its status changes.
- **Minor Past Producer Abandoned, Minor Past Producer Care and Maintenance, Minor Past Producer Renewed Exploration:** a past producer which produced <100,000 tonnes of ore.

- **Advanced Exploration:** a deposit which is well understood in three dimensions. Generally this means enough work has been done on which to base resource calculations.
- **Drilled:** the showing has been tested by at least one drill hole, not including small portable drill with small diameter core or holes less than three metres deep. Generally surface work has been done as well.
- **Local Examination:** sampling and ground investigations such as grid-based surveys have been carried out to further knowledge of the site. These may include trenching but not drilling.
- **Reconnaissance:** preliminary examination of an area has revealed a site of interest.

Table 10. Mineral Occurrences in Study Area. *Number of each type of mineral occurrence in the study area. * includes rounding errors.*

Development Stage	Number of occurrences	Percentage of total
Producer	3	0.0
Past Producer	37	3.8
Advanced Exploration	52	5.3
Drilled	259	26.4
Local Examination	259	26.4
Reconnaissance	370	37.7
Total	982	100.0*

While it would have been possible to evaluate each of the six Development Stages by pair-wise comparison, and thereby arrive at a Development Stage score for each occurrence, we felt this level of differentiation did not have sufficient resolution. Therefore, our panel of experts were asked to score the individual occurrences that were classed as "Drilled" Development Stage or higher rankings (n = 351). As a starting point, a base score was provided to the panel. The base Development Stage score (Gal and Martin, 2015), is shown in Table 11. In the current study, the experts were asked to call upon their own knowledge and experience, and to review the NORMIN-NUMIN database entries, to score the occurrences, given the base score only as a starting point. Panelists were free to amend this base score according to their judgement.

Table 11. NORMIN/NUMIN Base Scores Base score applied to each mineral occurrence in the study area by Development Stage.

Development Stage	Base Score
Producer	9
Past Producer	8
Advanced Exploration	7
Drilled	5
Local Examination	3
Reconnaissance	1

In the base score scheme, there are gaps in the gradation of base scores to account for criteria which indicate significant development between stages. However, there are several "Minor" Past Producers, mostly dating to the first half of the twentieth century, which had very little ore produced, and in practical terms the workings that produced the ore likely contributed less to the understanding or development of the mineralization than a few well-placed drill holes might have. Therefore some Past Producers might have unwarranted high base scores.

There is a further shortcoming with these base scores, particularly from the standpoint of road route planning. Specifically, the “Advanced Exploration” stage includes a number of large deposits that may be moving toward a production decision, with a long planned mine life. From the perspective of a road building project, it is these occurrences that should have arguably the greatest influence on road routing. However, there is a considerable range in the character of “Advanced Exploration” occurrences in the databases.

The lower level categories, “Local Examination” and Reconnaissance” (n = 629) were not examined in detail due to time and budgetary constraints, except in a few cases. The expert panel was instructed to scan through the list of occurrences, and if they knew a particular occurrence to warrant a better score for some reason, to feel free to alter that score. Overall, most of these lower ranked occurrences stayed at the base score.

In Gal and Martin (2015), three experts (including the first author) scored mineral occurrences, and the average value was used to characterize development stage. As there are no overlaps between the 2015 group and the current expert panel, the 2015 scores have been retained to obtain a weighted average score for each occurrence. In addition, the 2015 study included a larger area, so several mineral occurrences not considered by the current group were evaluated.

7.7.2 Commodity

The commodity was obtained from the NORMIN and NUMIN databases. It is not meant to be an exhaustive list of all possible commodities that could be found and produced from the SGP. For this study, only the primary (first listed) commodity was considered, although for many NORMIN-NUMIN entries, several commodities are listed together. In reality, many mineral deposits feature a suite of metals or minerals that are typical of the type of deposit in which they occur. For example; volcanic-hosted massive sulphide deposits commonly contain a copper-zinc-gold-silver assemblage, or a zinc-lead-silver assemblage. Lithium-bearing pegmatite may also have tantalum, niobium, and beryllium.

Commodities are grouped by convenience, rather than strict metallogenic groupings. Gold (55%), copper (10%), zinc (9%) and lithium (5%) made up the majority of primary commodities listed for the southern SGP. Diamond or kimberlite accounted for only about 2% of occurrences, although the economic value of some of these occurrences is well understood.

Panelists assigned a score from 0.1 to 9.9 for each commodity group. The commodity scores in Table 12 are the average from the expert panel (n = 8), weighted against the average from three other reviewing geoscientists in Gal and Martin (2015). Those NORMIN-NUMIN entries that did not list a primary commodity were assigned one based on a review of the occurrence description.

Table 12. Scoring of Primary mineral Commodities. Primary commodities from NORMIN-NUMIN database, with the weighted average (2015 and 2019) scores.

Primary Commodity (first listed in NORMIN-NUMIN)	Weighted average score
Diamond, kimberlite	8.95
Gold, silver, platinum, palladium	8.40
Base metals (zinc, copper, lead, molybdenum)	6.93
Strategic metals (Nb, Ta, REE, U, Th, Li, Be)	6.56
Base metals (cobalt, nickel, tungsten, tin)	6.31
Base metals (titanium, iron, vanadium, chromium, manganese, sulphide, sulfur)	4.96
Gems, semi-precious stones (amethyst, beryl, cordierite)	3.60
Industrial minerals (barium, fluorite)	3.30
Carving stone, Exotic stone	2.85
Building stone	2.35
Industrial minerals (asbestos)	1.02

In comparing 2019 and 2015 results, the strategic metals group was considered relatively more important and the base metals slightly less so. Diamonds and precious metals remained the highest scoring commodities through both studies.

It should be noted that the commodity will have a bearing on road use during the production stage of a mine. Certain commodities, such as diamonds, are produced on site in largely mechanical separation plants, and the production can be flown out on a regular basis. Base metal mines generally have a mill on site that produces concentrate to be shipped to a smelter. Those mines that ship a concentrate, or minimally processed product, will exert the heaviest demand on roads in the production stage.

7.7.3 Reserves-Resources

As established by NORMIN-NUMIN guidelines, only occurrences that are rated Advanced Exploration or higher have resource estimates. In this study, we considered National Instrument 43-101-compliant resource or reserve estimates (http://web.cim.org/standards/) as well as non-compliant, outdated or rough estimates of resources. The former were obtained from searching the websites of the operating companies for technical reports or news releases with current estimates, while the latter were taken from the NORMIN-NUMIN databases.

In characterizing a mineral occurrence, a resource will reinforce the Development Stage by indicating some standard of exploration work done (often chiefly drilling) to better understand the deposit. While it is necessarily dependent on a certain Development Stage being attained, we felt that an evaluation of resources would augment the mineral occurrence scoring.

The six classes of resource estimates (Table 13 below) were evaluated by eight panelists through pair-wise comparison. This is in contrast to Gal and Martin (2015) where a simple score was given by the authors. Evaluators were asked to indicate degree of preference for the different resource estimate classes, as a degree of confidence in the understanding of a deposit, in the context of mineral potential.

The resulting scores from pair-wise comparisons were converted to award the maximum of 9 points to the highest scoring variable (Proven Reserve) with the other variables in proportion (Table 13). This was done in order to facilitate a weighting amongst Reserves-Resources, Commodity, and Development Stage, as the latter two variables were simply scored.

It should be noted that only a very small number (n = 13) of mineral deposits (or deposit groups) have 43-101 compliant resource estimates attached, and less than 200 mineral occurrences have any sort of resource estimate at all attached to them. The highest confidence level attained in the resource estimate was used to characterize a particular resource, as these estimates often include several levels of confidence (i.e., estimates of both reserves and resources for advanced mineral properties).

Table 13. Scoring of Mineral Resources. Average score from panelists, recalculated to make Proven Reserve = 9.0. This scoring facilitated weighting with Commodity and Development Stage, as explained in text.

Resource or reserve	2019 Score (eight evaluators) – expressed as a maximum of 9.0
Proven Reserve	9.00
Probable Reserve	6.58
Measured Resource	5.56
Indicated Resource	3.92
Inferred Resource	1.92
Non 43-101 compliant estimates	0.53
No estimates	0.00

7.7.4 Value of Resource

The size and/or value of a mineral resource was not evaluated in this case, as that aspect was considered with the Development Stage scoring.

7.7.5 Mineral Occurrence Scoring

The Development Stage, Commodity, and Resource-Reserve components are inter-related, in that every entry in the NORMIN-NUMIN databases is at some Development Stage, for which there is a corresponding Commodity; and every Resource-Reserve entry has a corresponding Development Stage (albeit mainly restricted to Advanced Exploration or higher).

Because of this inter-relation, which is intuitively additive, some weighting is desirable. In Gal and Martin (2015) the Development Stage was considered most important in evaluating an area's mineral potential (rather than an individual deposit's value). Secondary considerations (assuming an unbiased explorer) were Reserve-Resource (because it indicates something is there in measurable quantities), and Commodity. Gal and Martin (2015) arrived at a weighting scheme after some informal discussions.

In the current study, eight panelists were asked to express relative importance of the three factors by pair-wise comparison, in characterizing a mineral occurrence, in the context of mineral exploration. The average score was normalized to a percentage value (Table 14).

Table 14. Weighting Factors for Mineral Occurrences.

Weighting factors used to arrive at an aggregate score to characterize each mineral occurrence. The average of eight evaluators pair-wise comparisons, expressed as a percentage.

NORMIN-NUMIN Sub-variable	2019 Score (eight evaluators) – expressed as %
Development Stage	54.17%
Commodity	11.29%
Reserves/Resources	34.54%
Total	100.00%

In contrast to Gal and Martin (2015), the Development Stage was not so dominant a consideration, and the Resource/Reserve variable was considered to be significantly more important. As noted above, Resource/Reserve values are expressed only for a minority of mineral occurrences. Commodity was, in both studies, the least important consideration, and received roughly equal weighting in the two studies.

The mineral occurrences heat map utilizing the scoring and weighting schemes described above, is shown in Figure 11. Two large "hot" areas are readily apparent: The Ekati/Diavik area and Gacho Kue region, for their cluster of deposits with advanced Development Stages, favoured Commodities, and in most cases, robust Resource estimates.

Mineral occurrences in the south SGP study area with scores are included in a digital (.xls) file accompanying this report (Appendix II).

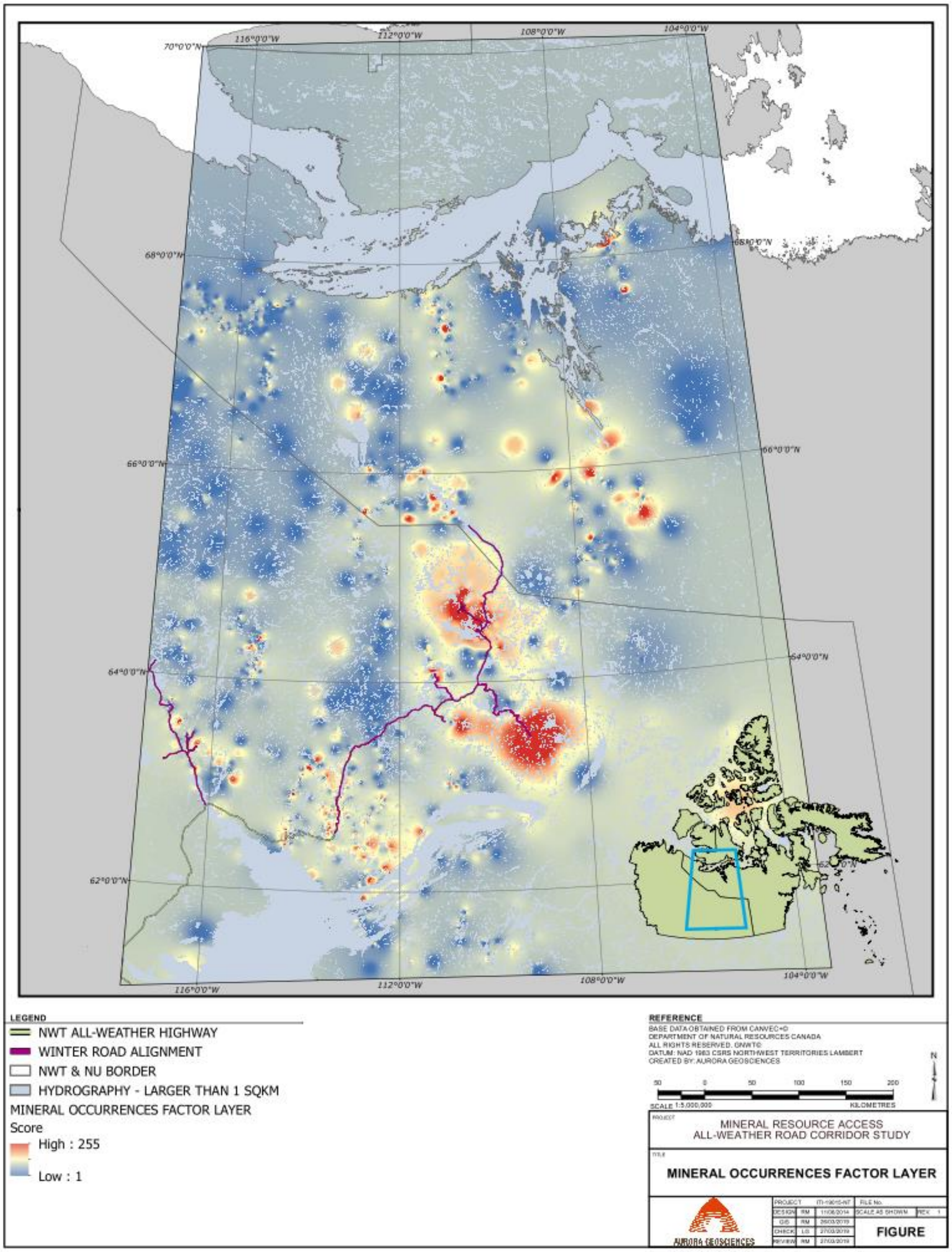

Figure 11. Mineral Occurrences thematic heat map.

7.8 OTHER DATA SETS

Several data sets that were deemed to lack direct bearing on mineral potential analysis, but did have a bearing on road routing, are included on the report maps. These include hydrology and wetlands, and general infrastructure.

7.8.1 Hydrology and Wetlands

Hydrology and wetlands (saturated soils) data was obtained from the NRCAN CANVEC+ dataset. Lake data were filtered to remove any water body less than 1 km^2. These elements were used as exclusion zones in the cost-path/cost-distance road route selection program, in order to have the computer choose possible routes that avoided lakes and wetland areas.

7.8.2 Surficial Geology

Although not a critical part of the mineral potential mapping exercise, surficial materials are important from both the standpoint of mineral exploration, development and road routing. New maps by the Geological Survey of Canada use fine-scale remote sensing data to produce a number of 1:50,000 scale map sheets throughout the north (Kerr et al., 2013). However, surficial geology was not considered in this project.

8 PAIR-WISE COMPARISON OF MINERAL POTENTIAL FACTORS

Gal and Martin (2015) had five panelists evaluate four factors (mineral occurrence, bedrock geology, mineral tenure, and faults) in the context of mineral potential by pair-wise comparison. In the current study we had eight panelists evaluate seven variables (mineral occurrence, bedrock geology, mineral tenure, faults, dykes, geophysical survey, and geochemical survey). While the 2015 study did not evaluate all the pairs that the current study did, we can still use the older results in a weighted average to improve the overall robustness of the scoring (13 evaluators in total). The geochemical survey factor was not used in the final analysis because the available data was not suited, but it was considered the third most important factor by the 2019 panel. For this reason, future studies should look to incorporate the geochemical survey data.

Table 15 below presents the weighted scores, expressed as a percentage, for the six factors.

Table 15. Mineral Tenure Pair-wise Comparison. Pair-wise comparison of mineral tenure types expressed as weighted average percentage values.

Mineral Potential Factor	Weighted Score (%)
Mineral Occurrence	30.97%
Bedrock Geology	29.26%
Fault	13.18%
Geophysical Survey	13.06%
Land Tenure	10.87%
Dyke	2.67%

As with the 2015 study, Mineral Occurrence and Bedrock Geology were deemed the most important factors (over 60% combined weight) and were also scored closely to one another. In the 2019 study, faults were deemed much more important. Figure 12 graphically compares the relative weightings of factors in Gal and Martin (2015) versus the current study.

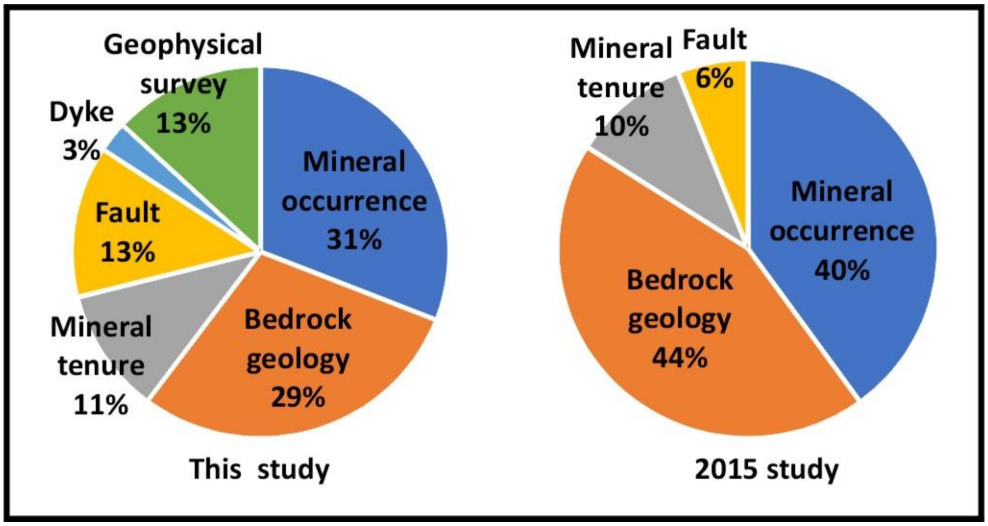

Figure 12. Relative factor weighting this study vs. 2015
Percentages are rounded.

9 RESULTS AND INTERPRETATION

9.1 MINERAL POTENTIAL MAP

Mineral potential map (Figure 1) shows that bedrock geology, and particularly the high-scoring volcanic greenstone belts, exert an influence on the interpreted mineral potential, but less strongly than in Gal and Martin (2015). Broad areas of high potential occur in the vicinity of the Ekati/Diavik and Gacho Kue/Kennady diamond deposits.

9.2 COST-PATH ROAD ROUTE MAP

From the mineral potential map, a GIS analysis function was employed to determine an optimal road route to maximize exposure to high mineral potential areas and minimize cost (distance). First a cost-distance function map was created using the inverse of the mineral potential map (to make the highest mineral potential the lowest "cost") and constraining the distance cost from any point along the existing NWT Highway system (i.e., NWT Highways 3 or 4). Also, wetlands and waterbodies of greater than 1 km^2 in area were avoided. River crossings were not considered. The destination was set at the Lockhart Lake camp (an ice road way station), and the mapping program determined the optimal path. The result is shown in Figure 2.

The optimal path departs the eastern terminus of Highway 4 at Tibbett Lake and bears generally northward, close to the path of the existing seasonal ice road, before diverging to run along the east shore of Gordon Lake. From there it essentially runs northeast and east to Lockhart Lake camp. The length of the optimal path is 151.26 km.

10 CONCLUSIONS

This GIS analysis was successful in using weighted, scored and rasterized maps of six key factors (bedrock geology, mineral occurrences, mineral tenure, geophysical surveys, dykes and faults) to map interpreted mineral potential in the SGP; and choose, through cost-distance and cost-path analysis, an ideal constrained road path to Lockhart Lake camp. The methodology is readily reproduced, and flexible enough to accommodate many different scenarios, route constraints, and imposed weighting factors of the main and additional variables.

Because the foundation of the data analysis was subjective and knowledge-based, there was an expectation that the modelled route would follow the volcanic greenstone belts, as they were scored the highest of the bedrock geology units (with kimberlite); and also pass close to, or toward, the largest and most advanced mining projects. These expectations were broadly met, and the advantage of the GIS mapping is that it somewhat filters personal biases. That said, as the mapping program relied on mainly subjective judgements, some biases may have occurred.

The updated bedrock geology dataset, and the increased number of subjective judgements, we feel has improved the result from the Gal and Martin (2015) study.

While there are limitations in the subjective analyses, the results are reasonable; and this study should be of value when used in concert with other work in choosing a final route.

11 LIMITATIONS AND RECOMMENDATIONS

As mentioned in the Disclaimer at the beginning of this report, the interpretations presented here cannot be considered stand-alone, nor can the report be considered static and final. Ongoing developments, in mineral exploration, will impact the mineral occurrence scores. Mineral tenures are almost always in flux. Therefore, this report presents a snapshot in time.

This analysis can be improved in several ways. Firstly, as with most subjective analyses, the additional participation of greater numbers of knowledgeable analysts will improve the scoring results, by moving toward (ideally) a normal distribution of scores.

Geophysical surveys have been considered in this study. The source geophysical survey database could be expanded, brought up to date, and refined to further subdivide survey types and resolutions. This would increase the number of variables to be considered and scored.

Geochemical surveys might also be used, or at least the “footprints” of such surveys. This will require restructuring and updating the existing database of till geochemistry and kimberlite indicator mineral surveys. Regional government surveys are lacking in the SGP, but the existing ones could be incorporated.

Further refinements to the geochemistry survey database might break out anomalous samples that could be evaluated.

Faults could be considered in more detail, perhaps grading fault segments based on mapped length, which could be considered as a proxy for the scale of the fault zone (width). However, the wider, major fault zones do not necessarily correlate with the best mineral potential, as mineral occurrences are often associated with smaller cross structures to the larger fault zones. The age and types of faults might also be considered separately.

Dykes were not judged to have a large influence on mineral potential, and this is unlikely to change, unless new metallogenic studies link particular dyke swarms to mineralization type.

A comprehensive, SGP-wide metallogenic compilation would be most helpful in outlining the most prospective geological units and illustrating mineral potential. Such a study should focus on the major commodities within the framework of mineral deposit models.

The ongoing digital compilation of surficial geology of the territories, led by Natural Resources Canada, should be used to inform road routing from the standpoint of road foundation materials, areas to be avoided, as well as aggregate sources.

Remote sensing data may be used in future work to outline bedrock outcrops, which might furnish road-building materials.

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