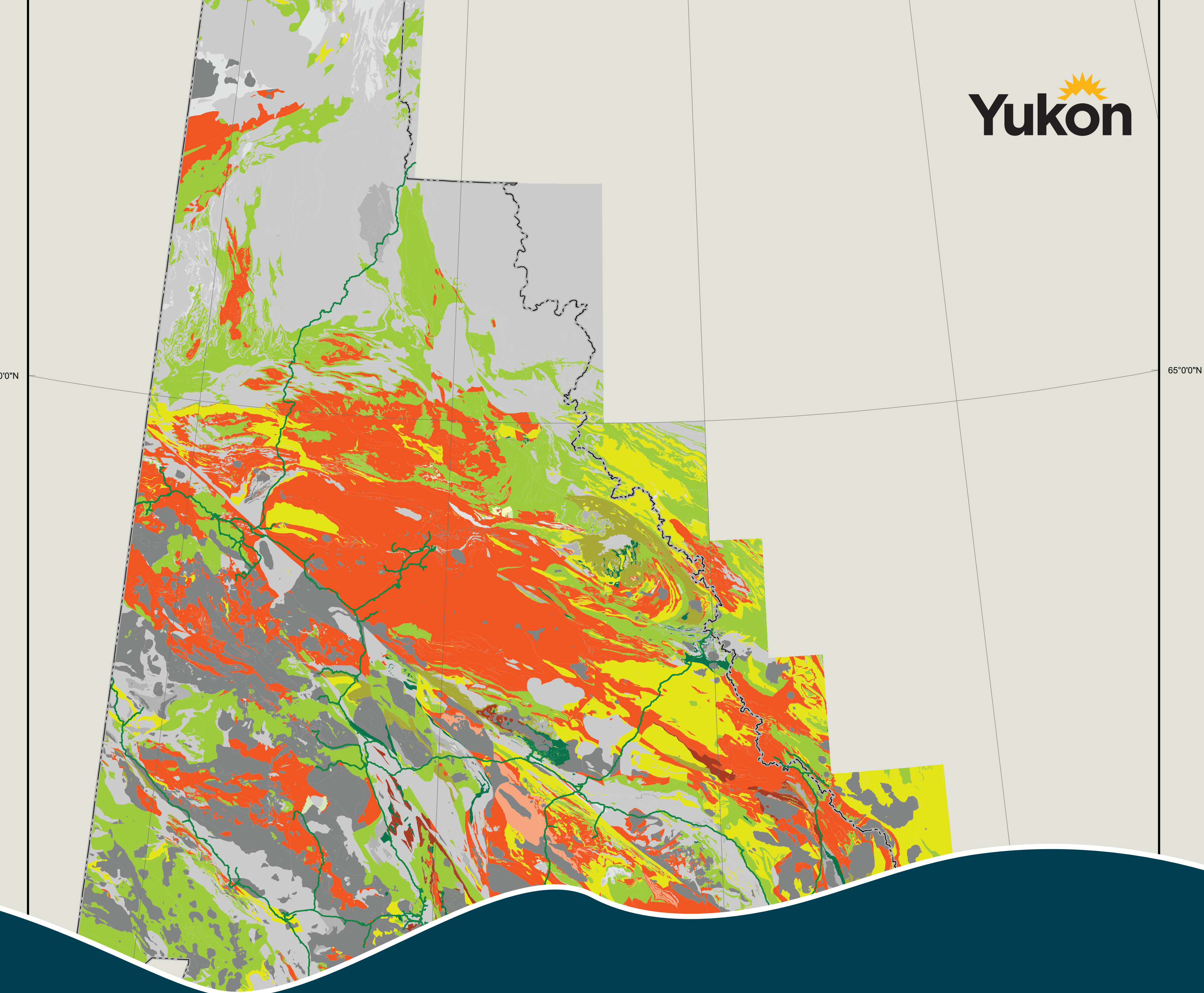


Yukon

Yukon Geological Survey Open File 2020-4

# Lithostratigraphic metallotect ranking of non-plutonic rocks in Yukon

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# Introduction

## Overview

The Yukon Geological Survey's lithostratigraphic metallotect project focuses on non-plutonic rocks in Yukon. The purpose of the project is to use the lithostratigraphic data in the Yukon bedrock geology geodatabase to rank geologic polygons in terms of their capability to host mineral deposits. Twelve specific mineral deposit models are considered; lithostratigraphic metallotect maps have been created for each deposit type. These maps and the associated table of metallotect rankings are envisioned as layers of information for mineral potential studies (*e.g.*, Bullen, 2020) and mineral exploration.

The methodology used in this project combines a lithostratigraphic metallotect rank with geologic mapping confidence. The lithostratigraphic metallotect rank considers lithologic suitability and mineral occurrence compatibility. This information is gathered from regional mapping, Yukon MINFILE, assessment reports, technical publications and mineral deposit models. The geologic mapping confidence rank is based on the lithostratigraphic level recorded in the Yukon bedrock geology database (YGS, 2019). The confidence rank increases with increasing geologic knowledge.

## Definitions

Deposit-type – basic descriptive and genetic model used to classify occurrences. Descriptions of each of these models are included in this report.

Lithostratigraphic metallotect – "A metallotect is a geological object whose presence can herald a deposit. It can be a fault, geological formation or stratigraphic contact controlling and guiding mineralization" (Jébrak and Marcoux, 2008; Laffitte *et al.*, 1965). In this report we use the lithostratigraphic attributes from the bedrock geology geodatabase (YGS, 2019) and apply the term lithostratigraphic metallotect.

Lithostratigraphic unit – a lithostratigraphic unit is a stratum or body of strata, generally layered and tabular, that conforms to the Law of Superposition and is distinguished and delimited based on lithic characteristics and stratigraphic position (North American Stratigraphic Code, 2005). In order of increasing geologic knowledge, this report uses the following lithostratigraphic levels: Supergroup, Group, Formation, Member and bed. When not defined, the lowest geologic confidence is assumed.

Lithostratigraphic combination – combinations are based on the lithostratigraphic units (UNIT_250K), rock classes (ROCK_CLASS and ROCK_SUBCLASS), and lithology (ROCK_MAJOR and ROCK_MINOR) data in the Yukon bedrock geology geodatabase (YGS, 2019). For this report, 993 unique lithostratigraphic combinations were extracted from more than 25 000 bedrock geology polygons in the geodatabase. These polygons form the spatial basis for evaluating metallogenic suitability for each deposit-type, and are referred to as lithostratigraphic polygons.

Lithologic suitability – assesses the suitability of each lithostratigraphic combination to host a deposit. It is used in the same sense as metallogenic epoch and province of Wilkinson and Kesler (2009), in that certain lithostratigraphic combinations are more suitable than others to host a given deposit type. For example, submarine volcanic rocks are more suited to volcanogenic massive sulphide deposits than Mississippi Valley-type massive sulphide deposits.

Lithostratigraphic metallotect rank – lithologic suitability and the presence of mineral occurrences within a lithostratigraphic polygon are used to determine a polygon's lithostratigraphic metallotect rank. Appendix 1 provides a table of lithostratigraphic metallotect rankings.

Mineral occurrence – any location where a naturally occurring concentration of minerals, rock or surficial material is found in a concentration of interest. The source of information used in this report is Yukon MINFILE.

Mineral occurrence compatibility – an evaluation of the consistency between the mineral deposit model ascribed in Yukon MINFILE and descriptions of mineralized rocks in assessment reports for each occurrence. Occurrences with deposit models consistent with assessment reports descriptions are considered compatible; those occurrences with significant discrepancies are not. For example, an occurrence with a skarn deposit model classification is compatible with assessment report descriptions that include calcareous host rocks, proximal intrusive rocks and skarn mineralogy.

Non-plutonic rock – includes sedimentary and volcanic rocks, and their metamorphic equivalents. In this report, the term refers to all rocks apart from the plutonic suites defined in Colpron *et al.* (2016a).

## Data used

The creation of lithostratigraphic metallotect rankings uses three primary data sets.

1. Yukon bedrock geology geodatabase (YGS, 2019), which contains lithostratigraphic data consistent with the hierarchical North American stratigraphic code (North American Stratigraphic Code, 2005). This is the geodatabase used to create the bedrock geology map of Yukon (Fig. 1). Lithostratigraphic data are combined with rock class and subclass data to create 993 unique lithostratigraphic polygons that have each been ranked for lithologic suitability. This report also uses the lithostratigraphic level as a measure of confidence in the geologic knowledge of a unit.
2. Yukon MINFILE database (YGS, 2018a), which includes more than 2500 mineral occurrences classified by a hierarchical deposit model scheme. In order of decreasing knowledge, the deposit model scheme goes from either epigenetic or syngenetic through to specific deposit models (Fig. 2). Only occurrences classified beyond the epi or syngenetic level are used to determine the metallotect rank.
3. Yukon assessment report footprints database (YGS, 2018b), which contains metadata and links to more than 8000 industry reports documenting mineral exploration activity over the last 70 years. Industry assessment reports document work conducted on a property in a given year. The level of detail and quality of these reports varies greatly, but they represent the best record of on-the-ground observations and are used to characterize and understand mineralization at each occurrence. In addition, a small number of occurrences, mostly deposits, have been studied in detail and sources such as theses and journal articles have been used to augment understanding of these.

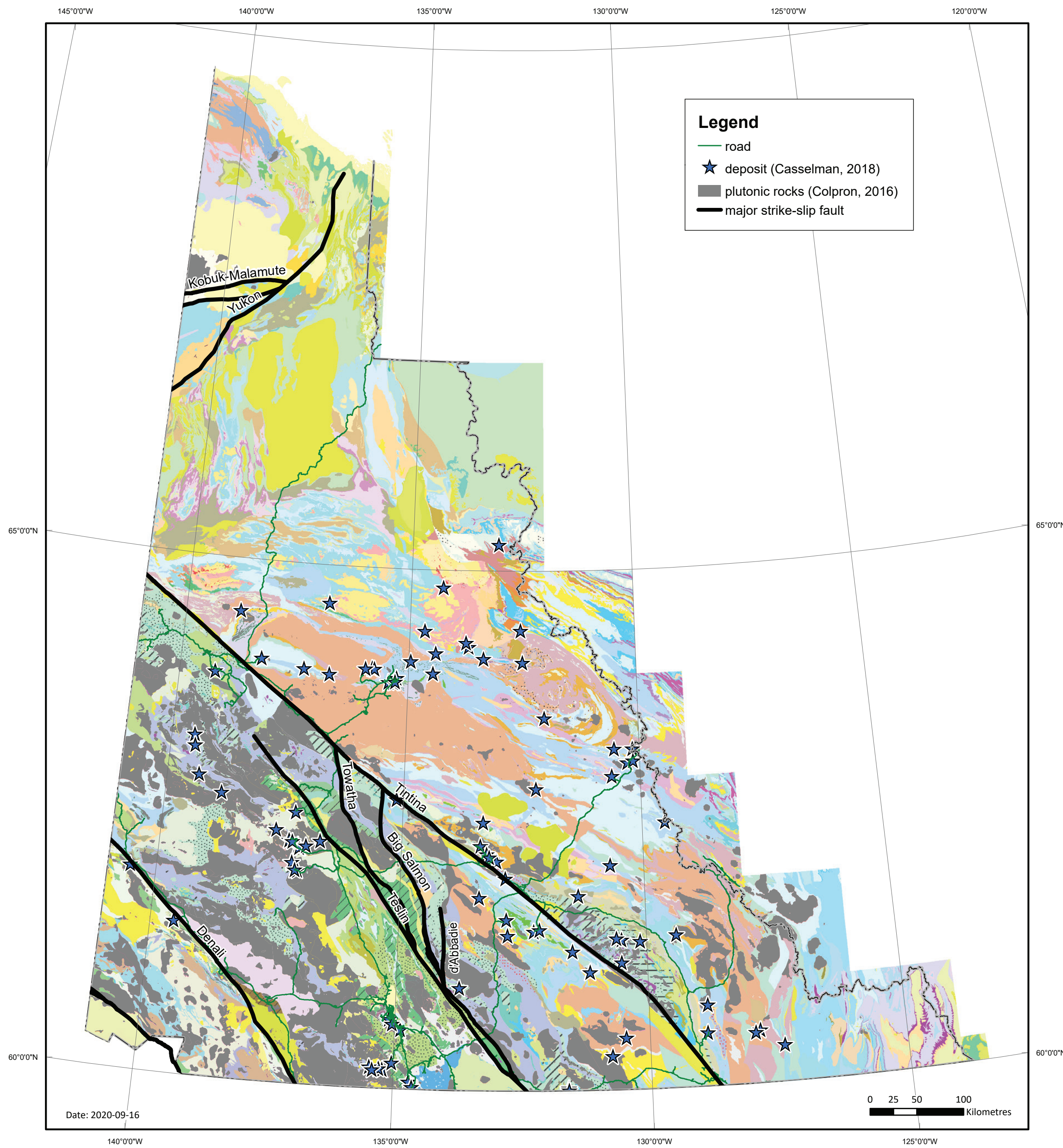


***Figure 1.*** *Yukon bedrock geology map. Geology legend as in Colpron et al. (2016b). Plutonic rocks are those in Colpron et al. (2016a). Major strike-slip faults shown as heavy black lines.*

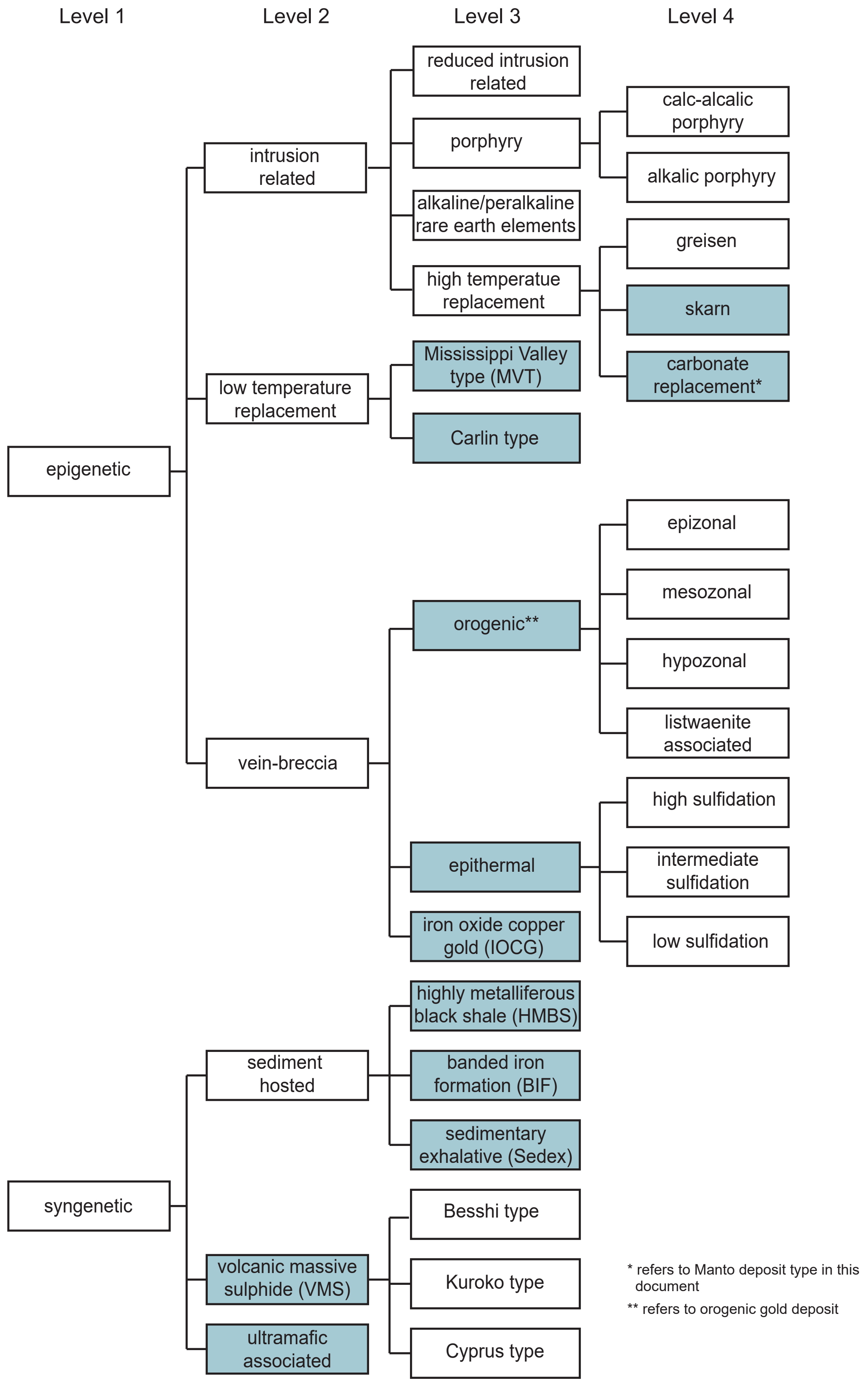


***Figure 2.*** *Hierarchical mineral occurrence deposit model classification scheme. Coloured boxes indicate models considered in this report.*

## Deposit models

Criteria used for the twelve deposit models considered in this report are described below.

### Ultramafic associated (UM)

Ultramafic rocks are the most suitable host lithology; lithologic suitability is extended to mafic rocks. Compatibility with the deposit model includes stratiform massive sulphides, or veins, pods and lenses of massive sulphide, a metal endowment of nickel, copper and platinum group elements (PGE) and the presence of sedimentary rocks as a sulphur source (Lesher, 2019). In Yukon, the best understood deposits of this type occur in the Kluane Ranges of southwestern Yukon, which host the Wellgreen deposit (Hulbert, 1993).

### Volcanic massive sulphide (VMS)

Volcanic massive sulphide deposits are hosted in marine volcanic and sedimentary rocks including felsic and mafic lavas or tuffs. Compatibility with the deposit model includes stratiform massive to semi-massive sulphides containing copper, lead and zinc, high barite content and the presence of exhalative rocks (Slack, 2010). In south-central Yukon, the Finlayson Lake district hosts a number of these deposits, including the past-producing Wolverine mine and Kudz Ze Kayah deposit.

### Sedimentary exhalative (Sedex)

Marine sedimentary rocks host sedimentary exhalative deposits. Compatibility with the deposit model includes stratabound lead and zinc sulphides frequently associated with barite, and an intra or epicratonic basin depositional environment (Emsbo, 2009). In Yukon, the best-known deposits are hosted in the MacMillan Pass, Howard's Pass and Anvil districts (Fonseca and Bradshaw, 2005); the Anvil district includes the past-producing Faro mine.

### Banded iron formation (BIF)

Banded iron formation deposits occur as bedded, chemically precipitated sedimentary rocks containing more than 15 weight percent iron (Bekker *et al.*, 2013). The lithologic suitability is extended to lithostratigraphic units mentioning "iron formation". The model indicates these deposits are primarily found in Proterozoic rocks and host-rock age is important for compatibility (Sial, 2015). The Crest iron deposit in north-central Yukon is the largest deposit of this type in western North America, and the largest undeveloped deposit in North America (Ootes *et al.*, 2013).

### Highly metalliferous black shale (HMBS)

Highly metalliferous black shale deposits typically occur in fine-grained, black siliciclastic rocks with high organic content. Compatibility with the deposit model includes stratabound to stratiform mineralized rock with a metal endowment that includes nickel and molybdenum. The lithologic suitability is extended to any highly carbonaceous units (Huyck and Grauch, 1989; Johnson, 2017). In Yukon, the only HMBS mineralization recognized occurs at the contact between the Canol Formation and the underlying Earn Group in north-central Yukon (Gadd *et al.*, 2019).

### Iron-oxide-copper-gold (IOCG)

Iron-oxide-copper-gold (IOCG) deposits occur in a wide range of rock types, but globally are mostly associated with granitoid rocks, andesitic metavolcanic rocks and metasiliciclastic rocks (Williams *et al.*, 2005). Compatibility with the deposit model includes a metal endowment with copper, gold, nickel, platinum group elements (PGE), uranium and rare earth elements (REE). In addition, mineralized rocks have breccia and lithology controlled replacement textures. In Yukon, the Wernecke breccia in north-central Yukon hosts the only known IOCG occurrences.

### Epithermal

High, intermediate and low sulphidation epithermal deposit types are considered together in this report. Epithermal deposits are commonly hosted in broadly coeval volcanic and volcaniclastic rocks. The lithologic suitability extends to a wide range of country-rock types, particularly those amenable to vein formation (*e.g.*, the ca. 76 Ma Klaza deposit hosted within the ca. 105 Ma Dawson Range batholith). Carbonate represents a less suitable lithology (John *et al.*, 2010). Compatibility with the deposit model includes presence of veins, breccia, stockwork and pods, with lead, zinc and copper sulphides and associated silver and gold. Surface exposure of coeval plutonic and volcanic rocks is an additional criterion. Eocene epithermal occurrences are well represented in the Wheaton district of southern Yukon. The Mount Freegold and Mount Nansen districts in central Yukon contain examples of Cretaceous occurrences (Fonseca and Bradshaw, 2005).

### Orogenic

In this study, the orogenic deposit model includes epizonal, mesozonal, hypozonal, and listwaenite associated deposit subtypes (Fig. 2). Host rocks consist preferentially of metamorphic rocks (regional greenschist to amphibolite metamorphic facies) and ultramafic rocks (listwaenite associated subtype). As the metamorphic gradient is not recorded within the Yukon bedrock geology geodatabase, lithologic suitability is extended to some sedimentary units. Compatibility with the deposit model includes mineralized rocks as discordant quartz and quartz-carbonate veins containing gold and minor sulphides (Groves *et al.*, 2003; Ash and Arksey, 1990). In Yukon, one of the better examples is the Late Jurassic Golden Saddle deposit in the White Gold district of central Yukon (Bailey, 2013).

### Carlin-type

Carlin-type deposits are found in silty limestone (Cline *et al.*, 2005). The lithologic suitability is extended to limestone associated with sandstone and siltstone. Compatibility with the deposit model includes mineralized rocks consisting of very fine grained gold associated with arsenian-pyrite that occur in breccia and stratabound disseminated zones. Decarbonatization and silicification are additional criteria (Hofstra and Cline, 2000). The only known examples of Carlin-type gold deposits in Yukon are in east-central Yukon along the Nadaleen trend, a 25-km-long alignment of recently discovered prospects on the northern margin of the Selwyn basin (Tucker *et al.*, 2018).

### Mississippi Valley-type (MVT)

Dolostone is considered the most suitable host rock; lithologic suitability is extended to limestone. Compatibility with the deposit model includes mineralized rocks as stratabound, vein and breccia bodies of lead and zinc sulphides. A lack of nearby igneous rocks is an additional criterion (Leach *et al.*, 1995). In Yukon, MVT deposits are hosted in Proterozoic to Paleozoic platformal carbonate rocks on the North America margin in north-central Yukon (Fonseca and Bradshaw, 2005).

### Manto

Manto deposits are the result of distal carbonate replacement mineralization associated with plutons. Limestone is considered the most suitable rock; lithologic suitability is extended to dolostone. Compatibility with the deposit model includes mineralized rocks as tabular, pod-like and pipe-like bodies that consist of copper, zinc and lead sulphides with associated silver (Plumlee, 1995; Ridley, 2013). In this report, occurrences are within 5 km of an intrusion. In Yukon, the Ketza River deposit in central Yukon is an example of a gold-rich polymetallic manto deposit that grades laterally into Ag-Pb-Zn ore bodies over 1 to 3 km (Cathro, 1990).

### Skarn

Skarns are found in, or near, calcium-rich rocks. Limestone is considered as the most suitable lithology; lithologic suitability is extended to any calcareous rock as well as mafic volcanic rocks. Compatibility with the deposit model includes calc-silicate mineralogy (e.g., pyroxene, garnet) as major rock-forming minerals. Mineralized rocks occur in vein and pods with a metal endowment that includes copper, molybdenum, tungsten, tin, zinc, lead, gold and silver (Hammarstrom et *al.*, 1991; Ray, 2013). In this report, the lithostratigraphic unit hosting the occurrence must be within 4 km of an intrusion. In Yukon, the MacTung deposit is a good example of this deposit type, as is the CanTung deposit just across the border in the Northwest Territories. These tungsten skarn deposits are preferentially associated with Cambro-Ordovician Rabbitkettle Formation silty limestone intruded by mid-Cretaceous granitic rocks. Copper skarns of the Whitehorse Copper belt in south-central Yukon are also associated with mid-Cretaceous granitoid rocks that intrude Triassic limestone (Fonseca and Bradshaw, 2005).

## Lithostratigraphic combinations and metallotect ranking

Unique lithostratigraphic combinations are extracted from seven attributes in the Yukon bedrock geology geodatabase: UNIT_250K, SUPERGROUP, GP_SUITE, FORMATION, MEMBER, ROCK_CLASS and ROCK_SUBCLASS. The 404 lithostratigraphic units (UNIT_250K, SUPERGROUP, GP_SUITE, FORMATION, MEMBER) are combined with rock classification attributes (ROCK_CLASS and ROCK_SUBCLASS) to make 993 unique lithostratigraphic combinations. These lithostratigraphic combinations reduce the >25 000 polygons in the bedrock geology geodatabase into 993 polygons, which provide the spatial and lithologic aspect of the project.

For each deposit model a lithostratigraphic metallotect rank from 1 (low) to 6 (high) is determined using lithologic suitability and compatibility of associated mineral occurrences (Fig. 3). Based on lithologic suitability, a rank of 1 is given when the lithostratigraphic combination is deemed not suitable for the deposit model, rank 2 when the combination is deemed unusual but possible, and rank 4 when the combination matches the deposit model well (Table 1). Based on mineral occurrence compatibility, a rank of 2 is increased to 3 and rank 4 to 5 when compatible mineral occurrences are found within the lithostratigraphic polygon; rank 5 is increased to 6 when one or more of the compatible occurrences are deposit status (Table 2).

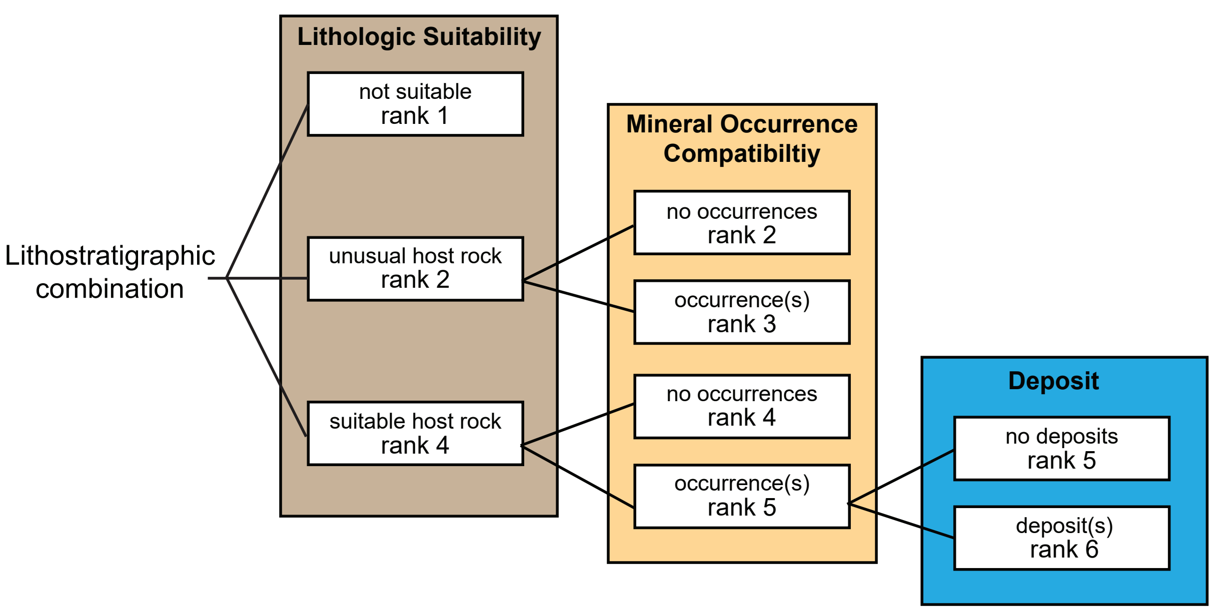


***Figure 3.*** *Summary of the procedure for populating the metallotect table.*

**Table 1.** *Summary of lithologic suitability for each deposit type. n/a = not applicable.*

| | Lithologic suitability rank 4 | | | Lithologic suitability rank 2 | |
|---|---|---|---|---|---|
| **Deposit type** | **ROCK_CLASS** | **ROCK_SUBCLASS** | **ROCK_MAJOR** | **ROCK_MAJOR** | **ROCK_MINOR** |
| Ultramafic associated | metamorphic, plutonic | mp_ultram, p_ ultram | ultramafics, peridotite, pyroxenite, dunite, harzburgite | serpentinite, listwaenite, greenstone | ultramafics, peridotite, pyroxenite, dunite, harzburgite |
| Volcanic massive sulphide | metamorphic, plutonic/ volcanic, volcanic, volcanic/ sedimentary | chert, m_chert, clastic/v_interm/ chert, clastic/v_ mafic, clastic/v_ mafic/v_felsic, mv_mafic, p_interm/v_felsic, v_felsic, v_interm/ mafic, v_mafic, v_mafic/v_felsic | lapilli tuff, volcanic breccia, flows, basalt, metavolcanics | metachert | lapilli tuff, volcanic breccia, flows, basalt, metavolcanics |
| Sedimentary exhalative | sedimentary/ volcanic, sedimentary, metamorphic | clastic, clastic/v_ felsic, clastic/chert, clastic/carbonate | chert/shale/argillite siliceous shale, chert, siltstone/ sandstone/conglomerate | sandstone/conglomerate/ tuff/breccia/flows/sills/ dikes/, argillite/volcanic/tuff/ limestone, sandstone/basalt/ conglomerate | argillite/phyllite, siltstone, sandstone |
| Banded iron formation | sedimentary | clastic | iron formation, siltstone/ diamictite/iron formation, mudstone/sandstone/ conglomerate | shale/siltstone/sandstone/ ironstone | n/a |
| Highly metalliferous black shale | sedimentary | carbonate/clastic, clastic, clastic/chert | black shale*, dark grey to black argillite*, black carbonaceous phyllite* | shale, argillite | n/a |
| Iron oxide copper gold | volcanic | v_hydrothermal | hematite breccia, heterolithic breccia, pyritic breccia | n/a | n/a |
| Epithermal | metamorphic, plutonic, plutonic/ volcanic, sedimentary, volcanic/ sedimentary | m_clastic, mp_ felsic, mv_mafic, p_mafic, clastic, clastic/v_mafic, v_felsic, v_interm/ clastic | quartzose psammite, quartzite/ basalt/flows, sandstone, siltstone, metaclastic schist, orthoquartzite, schist, rhyolite/ dacite | dolostone, chert | quartzite, siltstone/ sandstone/grit |
| Orogenic | metamorphic, plutonic, plutonic/ volcanic, sedimentary, volcanic | m_clastic, mp_ felsic, mp_interm, clastic, clastic/v_ mafic, mp_mafic/ ultram, mv_mafic, p_mafic, v_mafic/ interm | serpentinized ultramafic rocks, greenstone, undifferentiated schist, paragneiss, orthogneiss, phyllite | quartzite, volcanic sandstone, carbonaceous schist | volcanic, greenstone |
| Carlin-type** | sedimentary, metamorphic | carbonate/clastic, carbonate, clastic, m_carbonate, m_ clastic, m_clastic/ carbonate | dolostone, dolomite, limestone, calcareous sandstone, limestone/dolostone/chert/ volcanic, argillaceous limestone, calcareous shale, silty limestone, shale/ limestone, dolomite, silty and sandy dolomite, calcareous mudstone-siltstone | n/a | carbonate, limestone, dolostone, dolostone/calc-phyllite |
| Mississippi Valley-type | sedimentary | carbonate, clastic/ carbonate | dolostone, limestone | n/a | dolostone, limestone |
| Manto*** | sedimentary, metamorphic | carbonate, m_ carbonate | limestone | dolostone | limestone |
| Skarn**** | sedimentary, metamorphic | carbonate, m_ carbonate | limestone, marble, calc-silicate | dolostone | limestone, dolomite, marble |

* refers to rock description in the Yukon bedrock geology geodatabase

** combination of sedimentary clastic and carbonate

*** proximal with younger intermediate to felsic intrusive rocks

**** at contact with younger intrusive rocks

**Table 2.** *Summary of mineral occurrence compatibility for each deposit type.*

| Deposit type | Commodity | Deposit form | Other criteria |
|---|---|---|---|
| Ultramafic associated | Ni, Cu, PGE | stratiform, massive to stringers, net texture, pods, lenses | presence of a sedimentary rock as S source |
| VMS | Cu, Zn, Pb | stratabound massive sulphide | submarine volcanic and sedimentary rocks, associated barite and exhalite |
| Sedex | Zn, Pb | stratiform massive sulphide | intra and epicratonic rift system, associated barite and exhalite |
| BIF | Fe | layered, bedded, laminated magnetite or hematite | interlayered with chert, Proterozoic host rocks |
| HMBS | Ni, Mo | stratabound to stratiform | high carbon organic content |
| IOCG | Cu, Au, Ag, Pt, Pd, Ni, U, REE | brecciated, lithology controlled replacement | hematite and/or magnetite associated, intense hydrothermal alteration, no clear spatial association with pluton |
| Epithermal | Zn, Pb, Cu, Ag, Au | veins, breccia, stockworks, pods, lenses | associated subaerial volcanism |
| Orogenic | Au | vein, vein-breccia | quartz and quartz-carbonate veins, regional greenschist to amphibolite metamorphism facies, strong structural control |
| Carlin-type | Au | breccia, stratiform zones | impure carbonate showing decalcification and silicification |
| MVT | Zn, Pb | stratabound, breccia | not associated with igneous activity, relatively undeformed host rock |
| Manto | Cu, Zn, Ag, Pb | tabular pod-like and pipe-like | distal from igneous intrusive rocks, replacement texture |
| skarn | Cu, Mo, W, Sn, Zn, Pb, Au, Ag | veins, pods | spatial association with igneous intrusive rock, typically replacement rock forming mineral |

VMS = volcanic massive sulphide; Sedex = sedimentary exhalative; BIF = banded iron formation;
HMBS = highly metalliferous black shale; MVT = Mississippi Valley-type

## Lithostratigraphic metallotect ranking example: volcanic massive sulphide deposit type

Tables 3 and 4 provide an example of the process used to assign the lithostratigraphic metallotect ranks for the volcanic massive sulphide deposit type.

Table 3 illustrates the primary procedure for lithologic suitability ranking. Volcanic massive sulphide deposits are hosted by volcanic rocks deposited in submarine environments. For this deposit type, "sedimentary/carbonate" formations are unsuitable (rank 1), "sedimentary/clastic" rocks with minor tuff are not particularly suitable but mineralization may be present (rank 2), while metavolcanic rocks are suitable (rank 4).

***Table 3.*** *Example of lithologic suitability ranking for VMS deposit.*

| Lithologic suitability rank | ROCK_CLASS | ROCK_SUBCLASS | ROCK_MAJOR | ROCK_MINOR |
|---|---|---|---|---|
| 1 | sedimentary | carbonate | limestone | argillite/sandstone |
| 2 | sedimentary | clastic | slate/phyllite/limestone | dolostone/basalt/tuff/flows/sills |
| 4 | metamorphic | mv_felsic | ms-qtz phyllite, carbonaceous phyllite | chl phyllite |

mv = metavolcanic; ms = muscovite; qtz = quartz; chl = chlorite

In Table 4, mineral occurrence compatibility is assessed. The metallotect ranks 2 and 4 are upgraded to 3 and 5 respectively if there are VMS mineral occurrences. Finally, for one lithostratigraphic combination, two of the occurrences have deposit status (Casselman, 2018) and thus the metallotect rank of 5 is upgraded to 6.

***Table 4.*** *Example of lithostratigraphic metallotect ranking for VMS.*

| Litho-stratigraphic combination* | ROCK_CLASS | ROCK_SUBCLASS | ROCK_MAJOR | ROCK_MINOR | Lithologic suitability rank | Number of VMS occurrence(s) | Number VMS of deposit(s) | Litho-stratigraphic metallotect rank |
|---|---|---|---|---|---|---|---|---|
| CBD1 | sedimentary | carbonate | dolostone, limestone | shale/ limestone/ conglomerate | 1 | 0 | 0 | **1** |
| CSM5 | sedimentary | carbonate | limestone | tuff | 2 | 0 | 0 | **2** |
| ICG1 | sedimentary | carbonate, clastic | shale, siltstone, sandstone, calc-silicate | limestone, dolostone, mafic volcanics | 2 | 1 | 0 | **3** |
| CK1 | metamorphic | mv_felsic | porphyry/ rhyolite | <Null> | 4 | 0 | 0 | **4** |
| DMF1 | metamorphic | mv_mafic | amphibolite, bt-qtz schist, mafic gneiss | <Null> | 4 | 1 | 0 | **5** |
| DMF2 | metamorphic | mv_felsic | fp-ms-qtz schist | <Null> | 4 | 5 | 2 | **6** |

* Lithostratigraphic combination is abridged to lithostratigraphic code for table readability.

mv = metavolcanic; bt = biotite; qtz = quartz; fd = feldspar; ms = muscovite; qtz = quartz

## Geologic confidence

The geologic confidence is based on the lithostratigraphic level. It is derived from the Yukon bedrock geology geodatabase using the scoring chart shown in Table 5.

***Table 5.*** *Geologic confidence level chart derived from lithostratigraphic level.*

| Lithostratigraphic level | Geologic confidence level |
|---|---|
| undefined | 1 |
| Supergroup | 2 |
| Group | 3 |
| Formation | 4 |
| Member | 5 |
| Bed | 6 |

In instances where ambiguous terminology exists, the following two rules are used:

1. Lithostratigraphic units mentioning “undivided”, “undifferentiated” or “variegated”, having a question mark or more than one formation name, are downgraded to the next defined lithostratigraphic level (e.g., Formation becomes Group).
2. Confidence 3 is assigned to “unconsolidated” quaternary sediments by default.

## Lithostratigraphic metallotect table

The lithostratigraphic metallotect table consists of 20 columns and 994 rows – a sample is shown in Table 6. The table is designed to interface with the Yukon bedrock geology geodatabase using ArcGIS. Row 1 consists of column headers and the other 993 rows represent the unique lithostratigraphic combinations. Columns 1 through 7 correspond directly to lithostratigraphic and lithology data in the Yukon bedrock geology geodatabase. The seven attributes in these columns are grouped together to define the lithostratigraphic combinations. Column 8 is an estimate of geologic confidence based on the hierarchical lithostratigraphic code and level of units as previously described. Columns 9 through 20 contain the lithostratigraphic metallotect rank for each deposit type.

## Lithostratigraphic metallotect maps for each deposit-type

### Combining lithostratigraphic metallotect rank and geologic confidence

One approach to using the lithostratigraphic metallotect table is to combine the lithostratigraphic metallotect rank with the estimate of geologic confidence. For example, Table 7 illustrates the combination matrix used in the production of Figures 5 to 17a; grey is used when the lithology is not compatible with the considered deposit type, green to red colours correspond to an increase in lithostratigraphic metallotect rank, whereas the upward light to dark transition corresponds to an increase in geologic confidence. The combinations have been grouped for better readability of the map, resulting in a 4 × 3 matrix (Table 7).

**Table 6.** *Sample of the lithostratigraphic metallotect table. The metallotect ranking table consists of three sections: lithostratigraphic data (blue boxes), geologic confidence (green boxes), and lithostratigraphic metallotect ranking for each deposit-type (grey boxes). UNIT_250K: Yukon bedrock geology lithostratigraphic unit code; GP_SUITE: Group, UM: ultramafic associated; VMS = volcanic massive sulphide; Sedex = sedimentary exhalative; BIF = banded iron formation; HMBS = highly metalliferous black shale; IOCG = iron oxide copper gold; MVT = Mississippi Valley-type.*

| Unit_ 250K | Super group | GP_ Suite | Formation | Member | Rock_Class | Rock_ Subclass | Confidence | UM | VMS | Sedex | BIF | HMBS | IOCG | Epithermal | Orogenic | Carlin | MVT | Manto | Skarn |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CDB1 | | | Bouvette | | sedimentary | carbonate | 4 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 4 | 5 | 4 | 5 |
| CDB2 | | | Jones Ridge | | sedimentary | carbonate | 4 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 4 | 2 | 4 | 2 |
| CDB3 | | | Vunta | | sedimentary | carbonate | 4 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 4 | 2 |
| CDR | | Road River | | | sedimentary | clastic/ carbonate | 3 | 1 | 1 | 5 | 1 | 1 | 1 | 2 | 1 | 4 | 2 | 4 | 2 |
| CDR1 | | Road River | | | sedimentary | clastic/ carbonate | 3 | 1 | 1 | 4 | 1 | 1 | 1 | 2 | 1 | 4 | 2 | 4 | 2 |
| CDR2 | | Road River | | | sedimentary | clastic/chert/ carbonate | 3 | 1 | 1 | 4 | 1 | 1 | 1 | 2 | 1 | 4 | 4 | 4 | 2 |
| CDR3 | | Road River | | | sedimentary | clastic | 3 | 1 | 1 | 2 | 1 | 1 | 1 | 2 | 1 | 1 | 2 | 1 | 1 |
| CDR4 | | Road River | | | sedimentary | carbonate | 3 | 1 | 1 | 4 | 1 | 1 | 1 | 1 | 1 | 4 | 4 | 1 | 1 |
| CDR5 | | Road River | | | sedimentary | clastic | 3 | 1 | 1 | 4 | 1 | 1 | 1 | 2 | 1 | 2 | 2 | 1 | 1 |
| CDS1 | | St. Cyr | | | sedimentary | clastic/ carbonate | 3 | 1 | 1 | 5 | 1 | 1 | 1 | 3 | 1 | 2 | 2 | 4 | 4 |

**Table 7.** *Combined geologic confidence–lithostratigraphic metallotect rank chart used for Figures 5 to 17(a). The first number corresponds to the geologic confidence score; the second number corresponds to the lithostratigraphic metallotect rank.*

| | | | | | |
|---|---|---|---|---|---|
| 6-1 | 6-2 | 6-3 | 6-4 | 6-5 | 6-6 |
| 5-1 | 5-2 | 5-3 | 5-4 | 5-5 | 5-6 |
| 4-1 | 4-2 | 4-3 | 4-4 | 4-5 | 4-6 |
| 3-1 | 3-2 | 3-3 | 3-4 | 3-5 | 3-6 |
| 2-1 | 2-2 | 2-3 | 2-4 | 2-5 | 2-6 |
| 1-1 | 1-2 | 1-3 | 1-4 | 1-5 | 1-6 |

## Geologic confidence map

In Yukon, lithostratigraphic units are dominantly defined at Group and Formation level (Fig. 4; Table 8). These two levels represent more than 90% of the non-plutonic rocks in Yukon. Two of the areas mapped in detail correspond to the MacMillan Pass and the Faro-Anvil districts, both of which are associated with Sedex deposits discovered in the 1950s. The association between increased geologic knowledge (e.g., further subdivision of strata) and mineral deposits is unsurprising given the economic incentive to better understand how and where deposits form.

**Table 8.** *Percentage area by geologic confidence level for non-plutonic rocks in Yukon*

| Stratigraphic mapping level | Geologic confidence level | Area % |
|---|---|---|
| undefined | 1 | 2.5 |
| Supergroup | 2 | <0.5 |
| Group | 3 | 28.4 |
| Formation | 4 | 62.8 |
| Member | 5 | 6.2 |
| Bed | 6 | <0.01 |

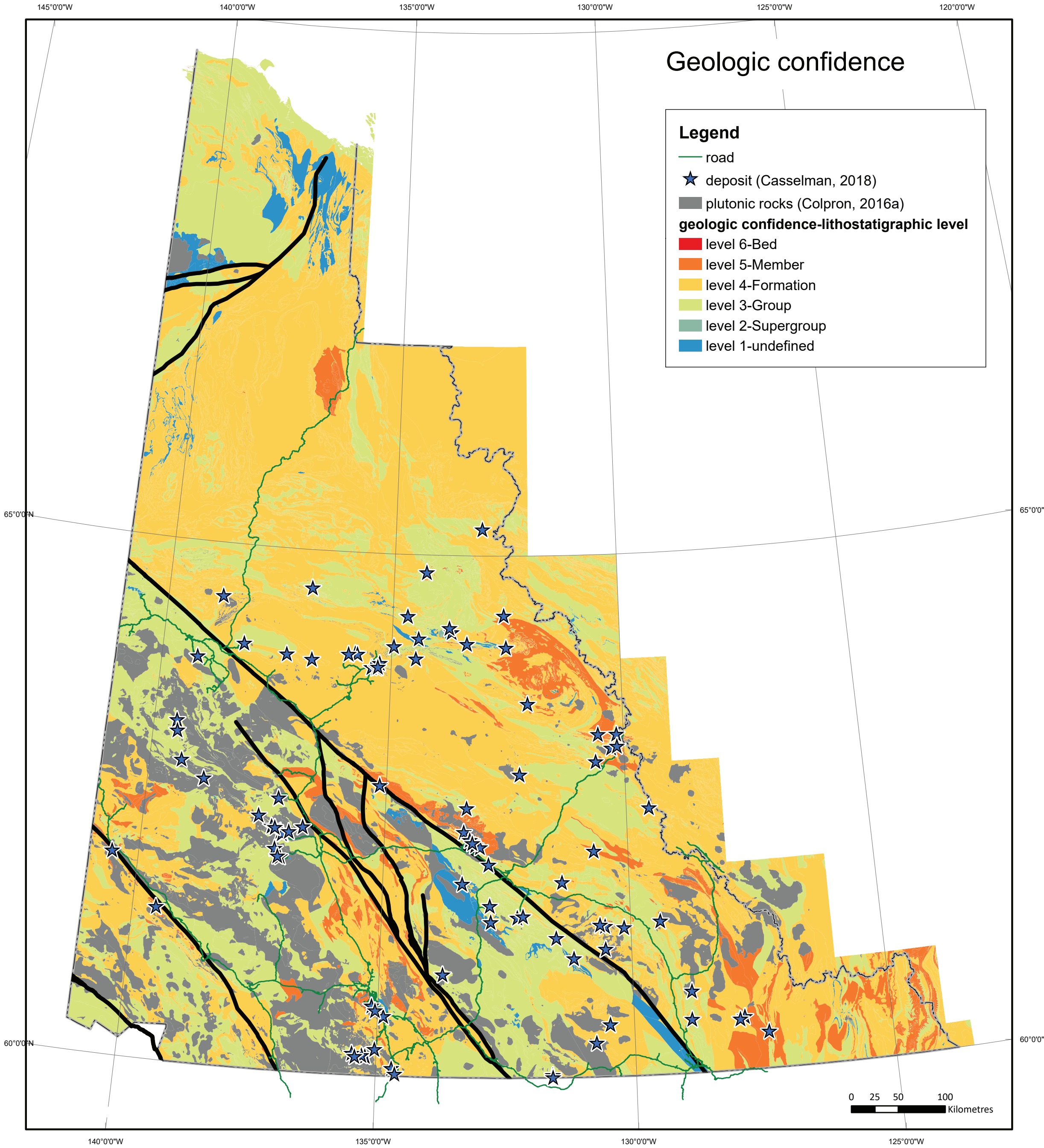


***Figure 4.*** *Map is colour coded by geologic confidence level. More than 60% of Yukon is mapped at Formation level (orange). Low geologic confidence level areas (blue) indicate undefined lithostratigraphic level. Faults as in Figure 1.*

## Lithostratigraphic metallotect maps

Figures 5 to 16 are page size examples of metallotect maps for the 12 deposit types considered. These maps are produced using the lithostratigraphic metallotect table (Appendix 1) and the Yukon bedrock geology geodatabase (YGS, 2019). Lithostratigraphic polygons are colour coded as in Table 7. These figures are for visualization only and the data are best utilized on scalable digitial platforms.

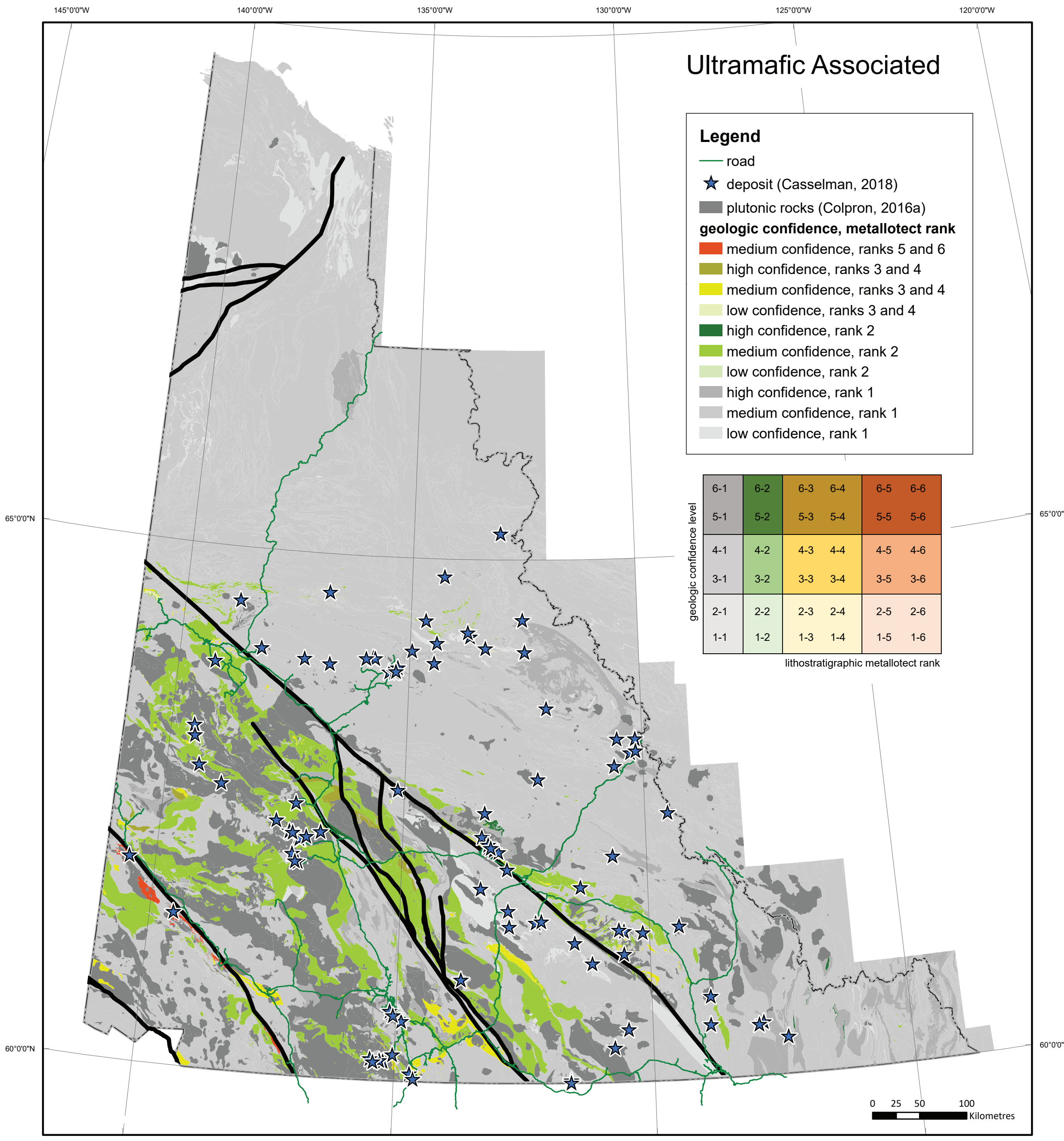


*__Figure 5.__ Ultramafic associated deposit type metallotect map. The highest lithostratigraphic metallotect ranks are concentrated in southwestern Yukon along the Denali fault. Based on present knowledge, no new prospective areas have been identified. Suitable rocks are predominantly found southwest of the Tintina fault. Faults as in Figure 1.*

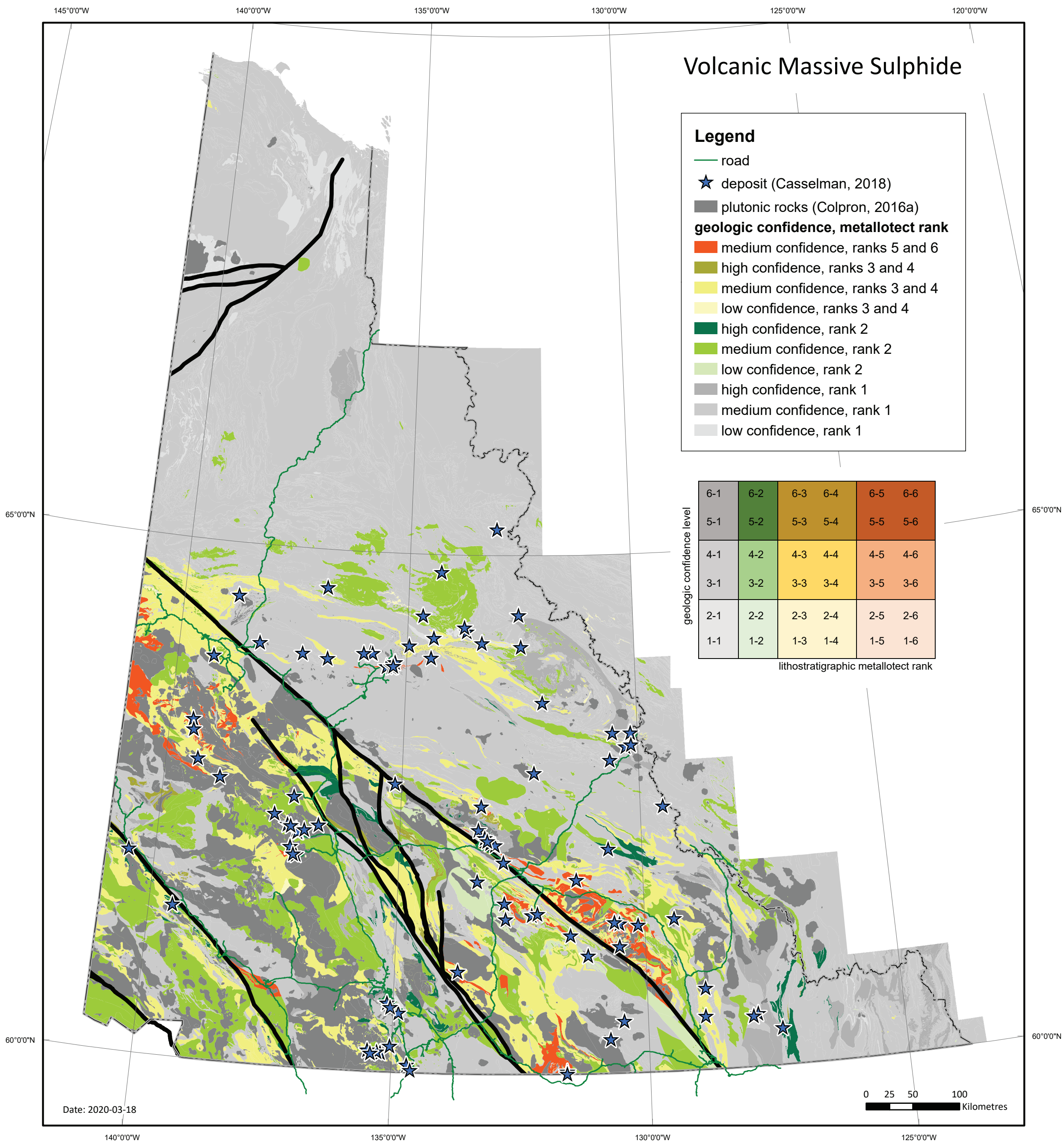


**Figure 6.** *Volcanic massive sulphide deposit type metallotect map. The highest lithostratigraphic metallotect ranks occurs in the Finlayson district. In the Dawson area, one occurrence has been identified within Finlayson assemblage, offset of by the Tintina fault. Southwest of the Tintina fault, occurrences meeting the VMS deposit criteria have been primarily identified within the Klondike schist unit. VMS deposits occur within correlative rocks in Alaska. Faults as in Figure 1.*

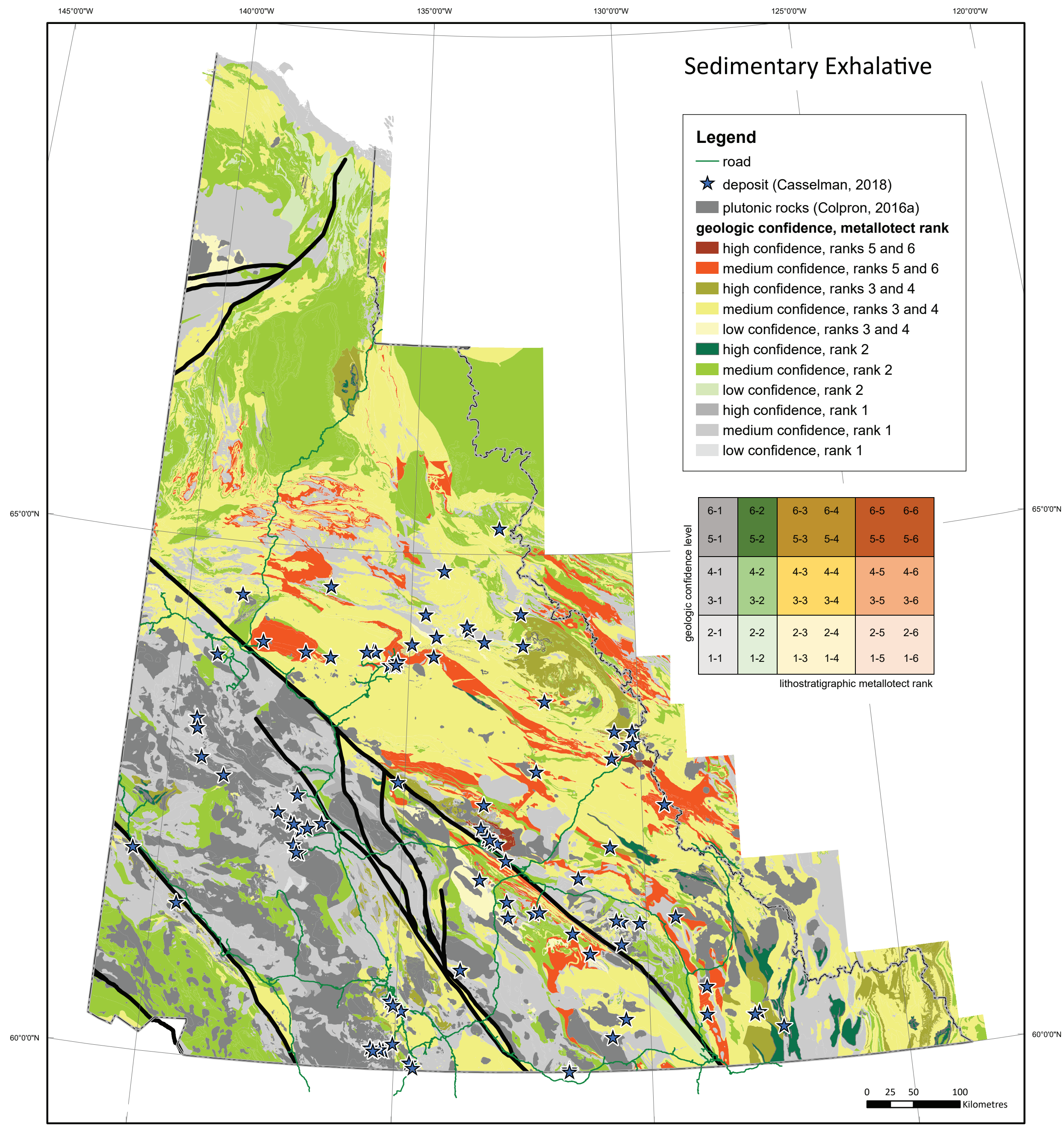


***Figure 7.*** *Sedimentary exhalative (Sedex) deposit type metallotect map. The highest lithostratigraphic metallotect ranks occur predominantly within Ordovician to Mississippian sedimentary rocks north of the Tintina fault. Faults as in Figure 1.*

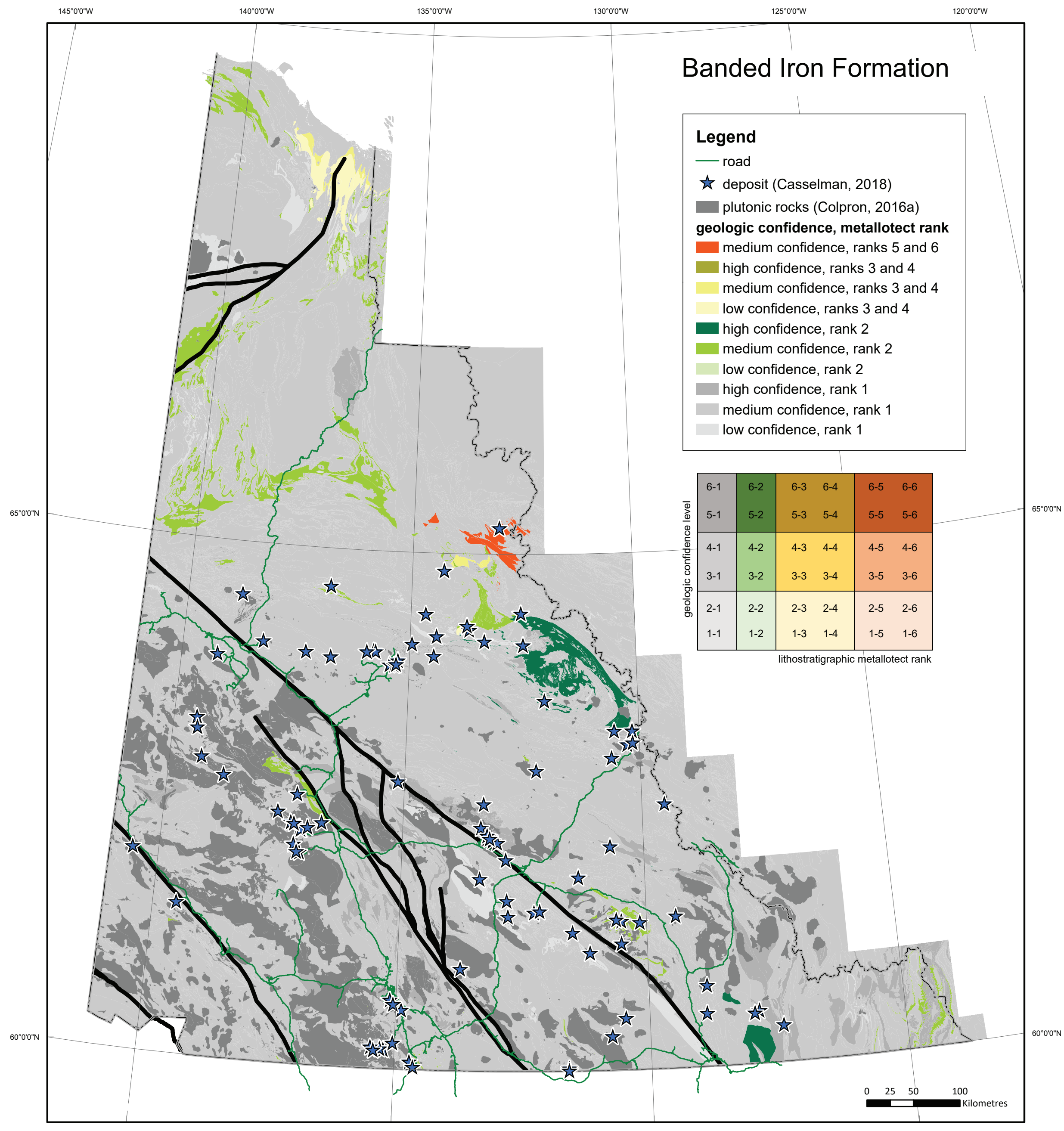


***Figure 8.*** *Banded iron formation (BIF) deposit type metallotect map. The map reflects the presence of the Crest Iron deposit in northeastern Yukon, at the border with the Northwest Territories. Based on present knowledge, the prospective lithostratigraphic units are limited to the Rapitan group. Phanerozoic banded iron formations are not expected in Yukon. The presence of minor iron formation within the lithostratigraphic metallotect combinations means some younger rocks are lithologically suitable. Faults as in Figure 1.*

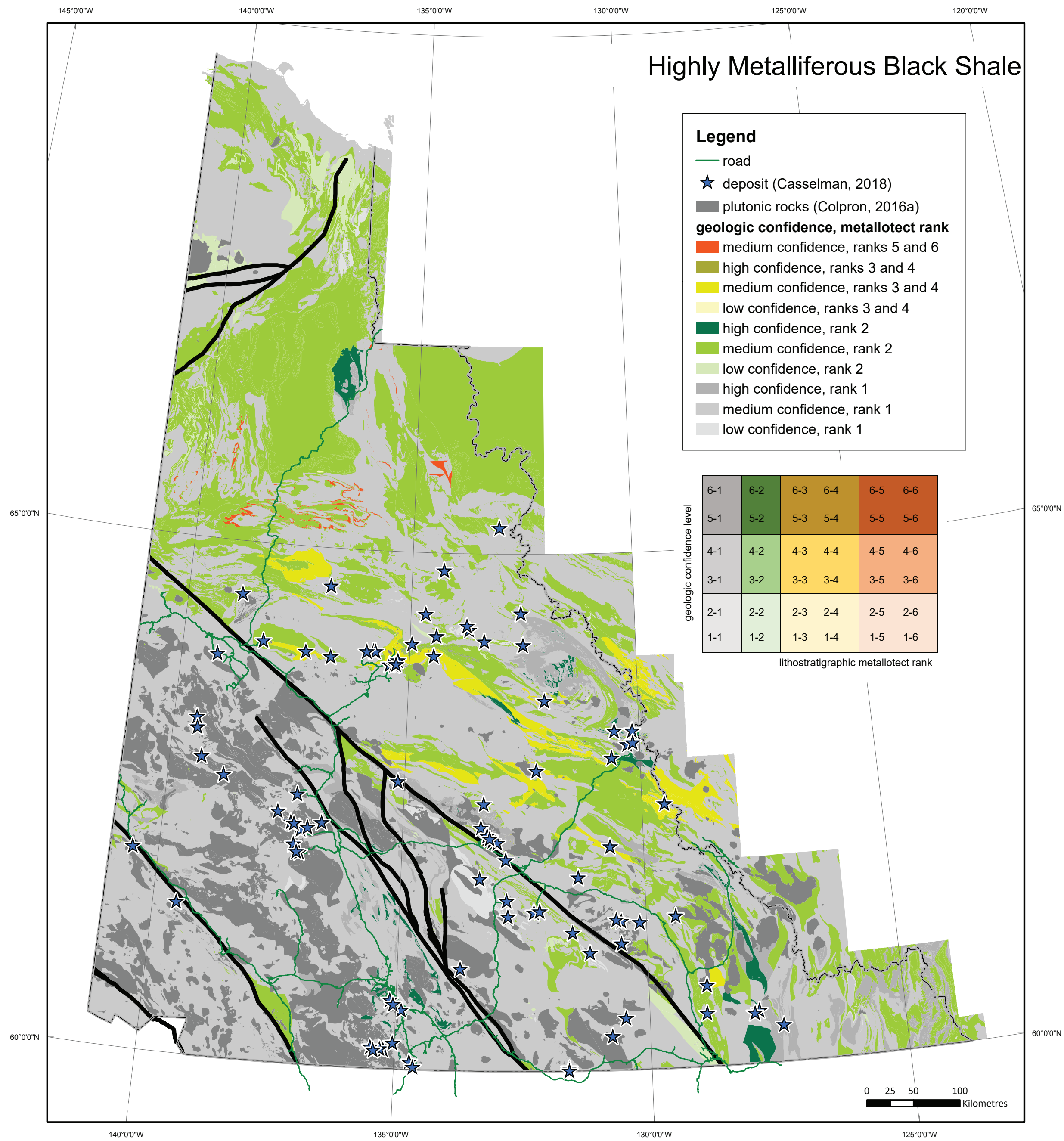


***Figure 9.*** *Highly metalliferous black shale (HMBS) deposit type metallotect map. Suitable rocks predominantly occur on the northern side of the Tintina fault and reflect high carbonaceous content lithostratigraphic combinations. The contact between the Canol Formation and the Earn Group constitutes the prospective lithostratigraphic horizon in Yukon. The known occurrences are located north of Dawson. Faults as in Figure 1.*

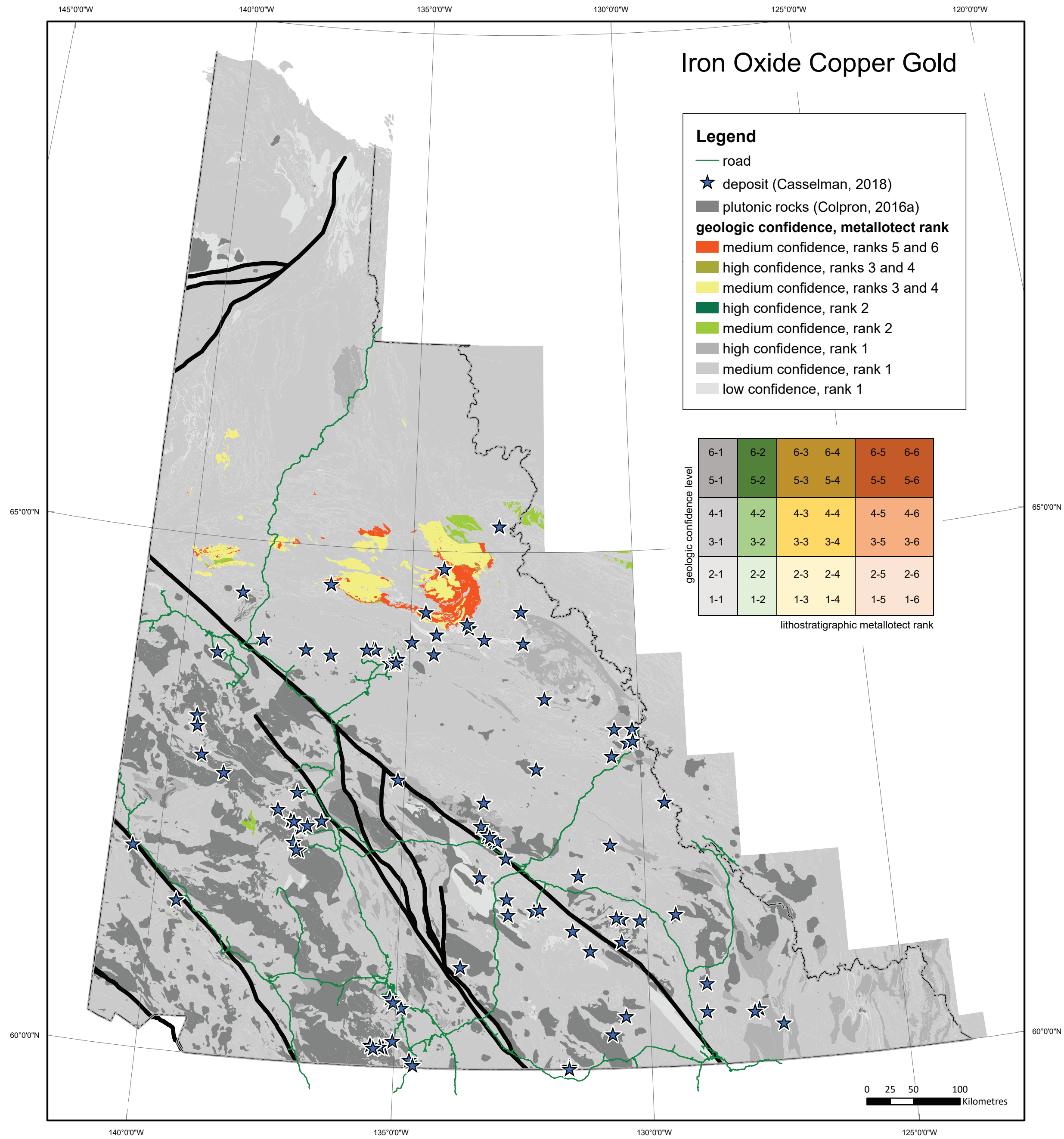


***Figure 10.*** *Iron oxide copper gold (IOCG) deposit type metallotect map. Suitable rocks are known to exist within the Wernecke Supergroup. The Wernecke breccia, which hosts mineralized rocks, is a mappable unit within north-central Yukon. Consequently, occurrences have been identified in the adjacent rock and the prospectivity is high within the formation surrounding the mapped Wernecke breccia. To date, no IOCG deposits have been identified elsewhere in Yukon and thus the corresponding lithostratigraphic metallotect rank is low. Faults as in Figure 1.*

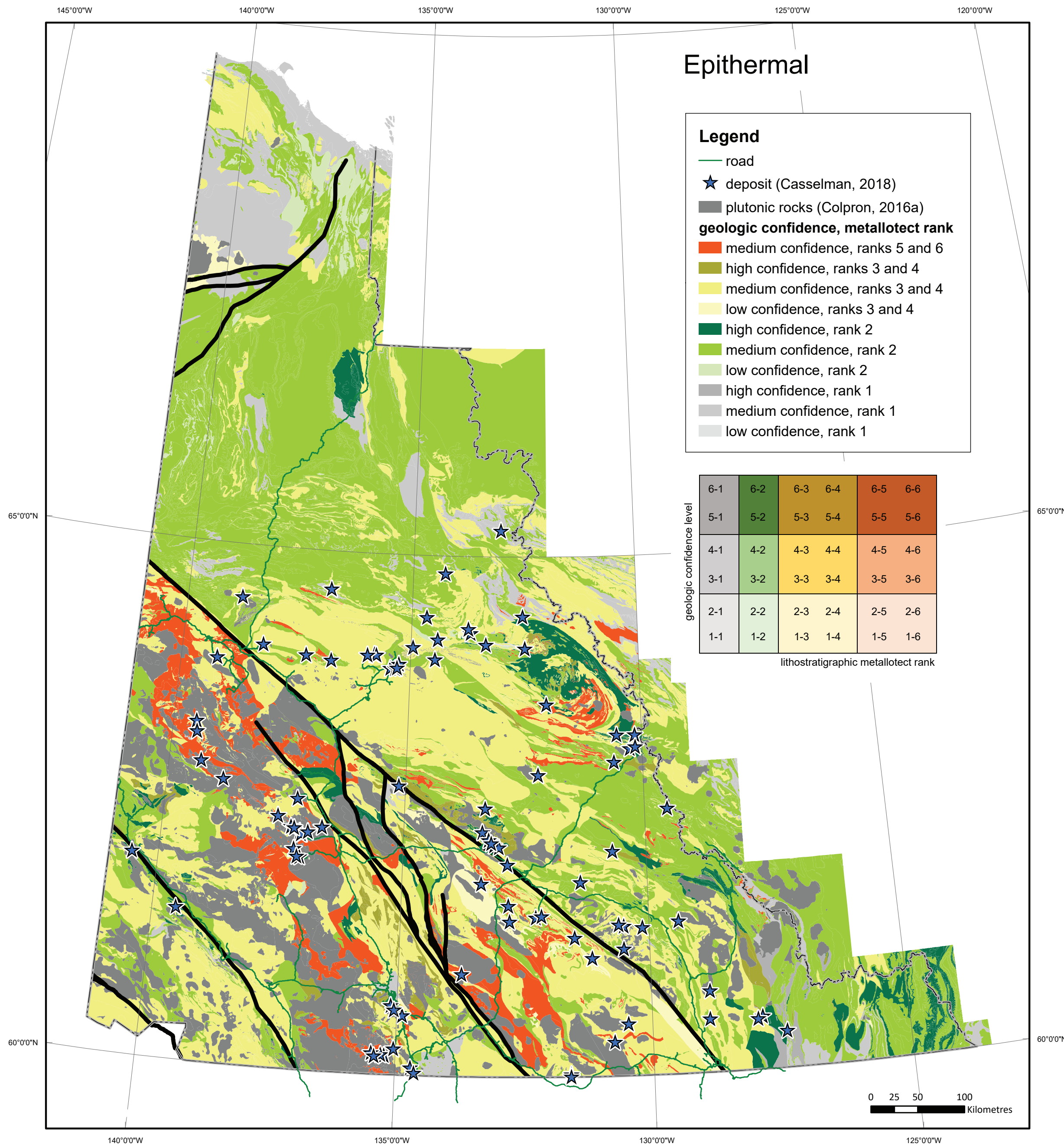


*__Figure 11.__ Epithermal deposit type metallotect map. Suitable rocks are found across a large area. Prospective areas are found along the Tintina fault and associated with subaerial volcanic rocks of the Yukon-Tanana terrane. Faults as in Figure 1.*

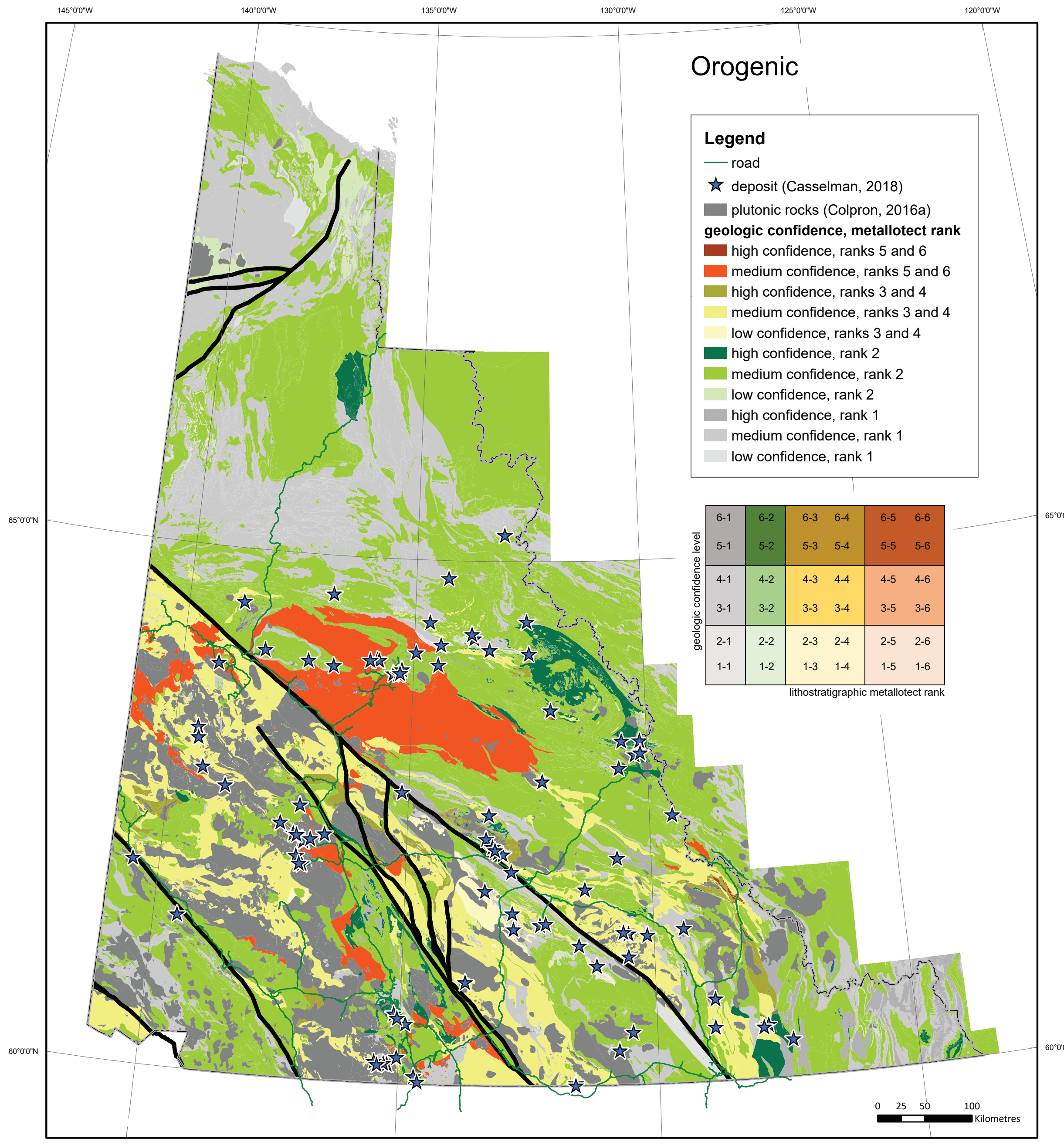


***Figure 12.*** *Orogenic deposit type metallotect map. Suitable rocks extend on both sides of the Tintina fault from the Watson Lake area to central Yukon near Dawson. Orogenic vein mineral occurrences are primarily found in the greenschist-grade rocks of the Yukon-Tanana terrane south of Dawson, but there have been several recent discoveries within lower grade metasedimentary rocks of the Hyland Group. Faults as in Figure 1.*

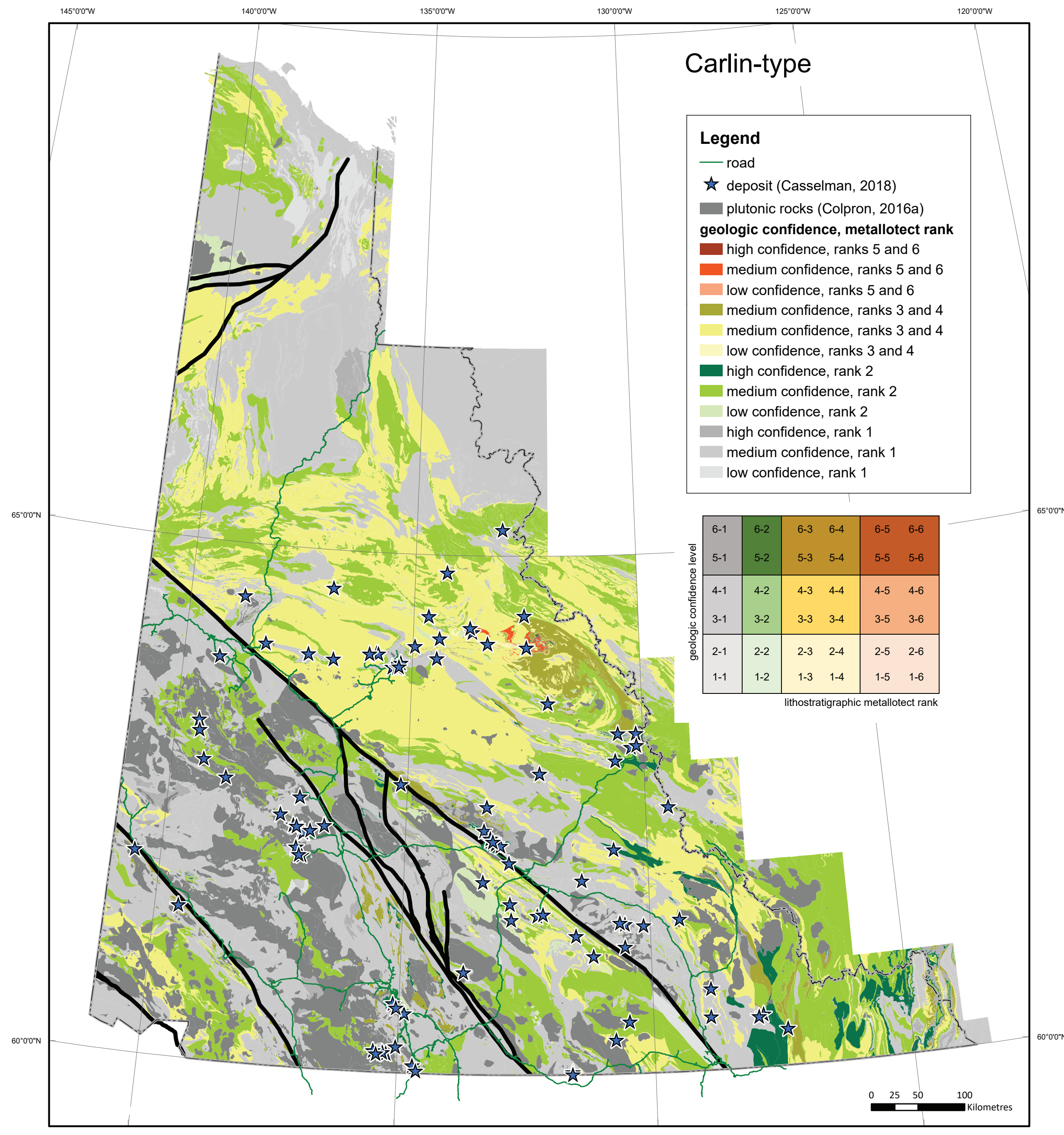


***Figure 13.*** *Carlin-type deposit type metallotect map. Suitable rocks predominantly occur in central Yukon. To date, mineral occurrences of this type are known along the Nadaleen trend between the Kathleen Lakes and Dawson faults. Faults as in Figure 1.*

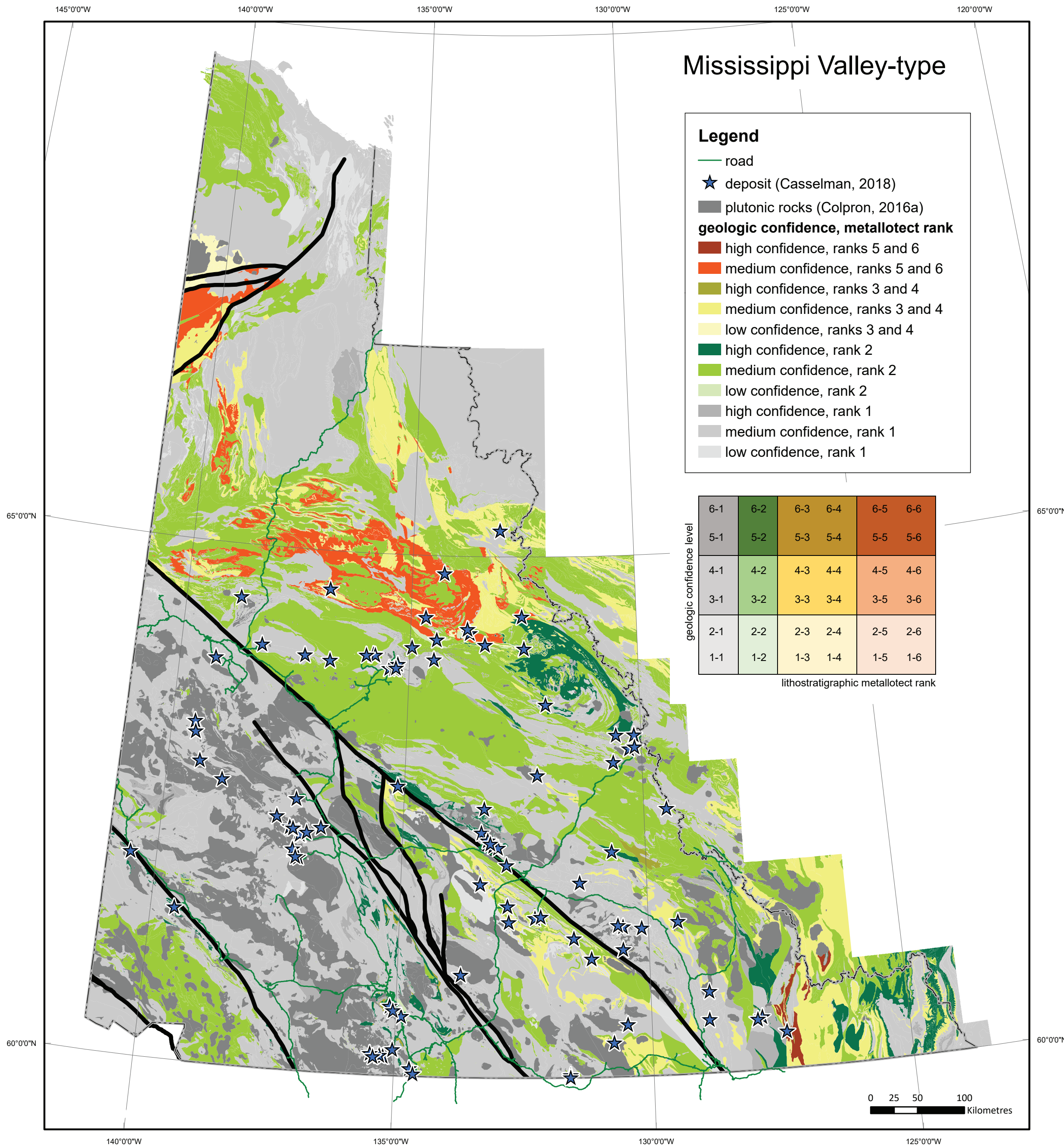


**Figure 14.** *Mississippi Valley-type (MVT) deposit type metallotect map. Suitable rocks occur predominantly in the Watson Lake area and north of Keno within platformal rocks associated with Laurentia. Most of the occurrences are concentrated in north-central Yukon. In the Watson Lake area, the Mel deposit constitutes a controversial marine sediment-hosted, stratabound, epigenetic deposit that most likely fits in the MVT model. Faults as in Figure 1.*

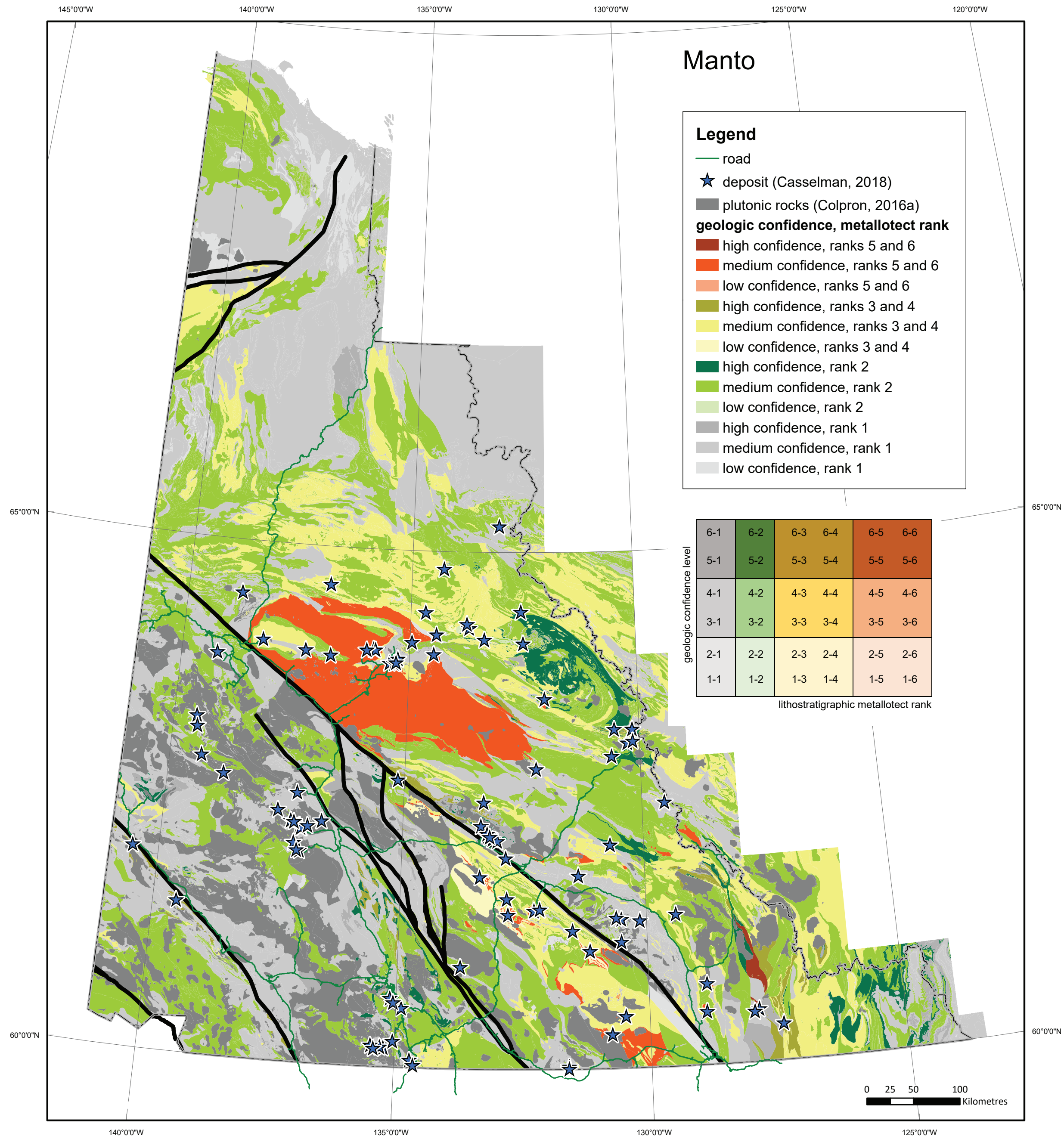


***Figure 15.*** *Manto deposit type metallotect map. Suitable rocks are predominantly located in the Watson Lake area and in central Yukon, north of the Tintina fault. A limited number of occurrence have been identified. They appear to be related to Cretaceous plutonic rocks. Faults as in Figure 1.*

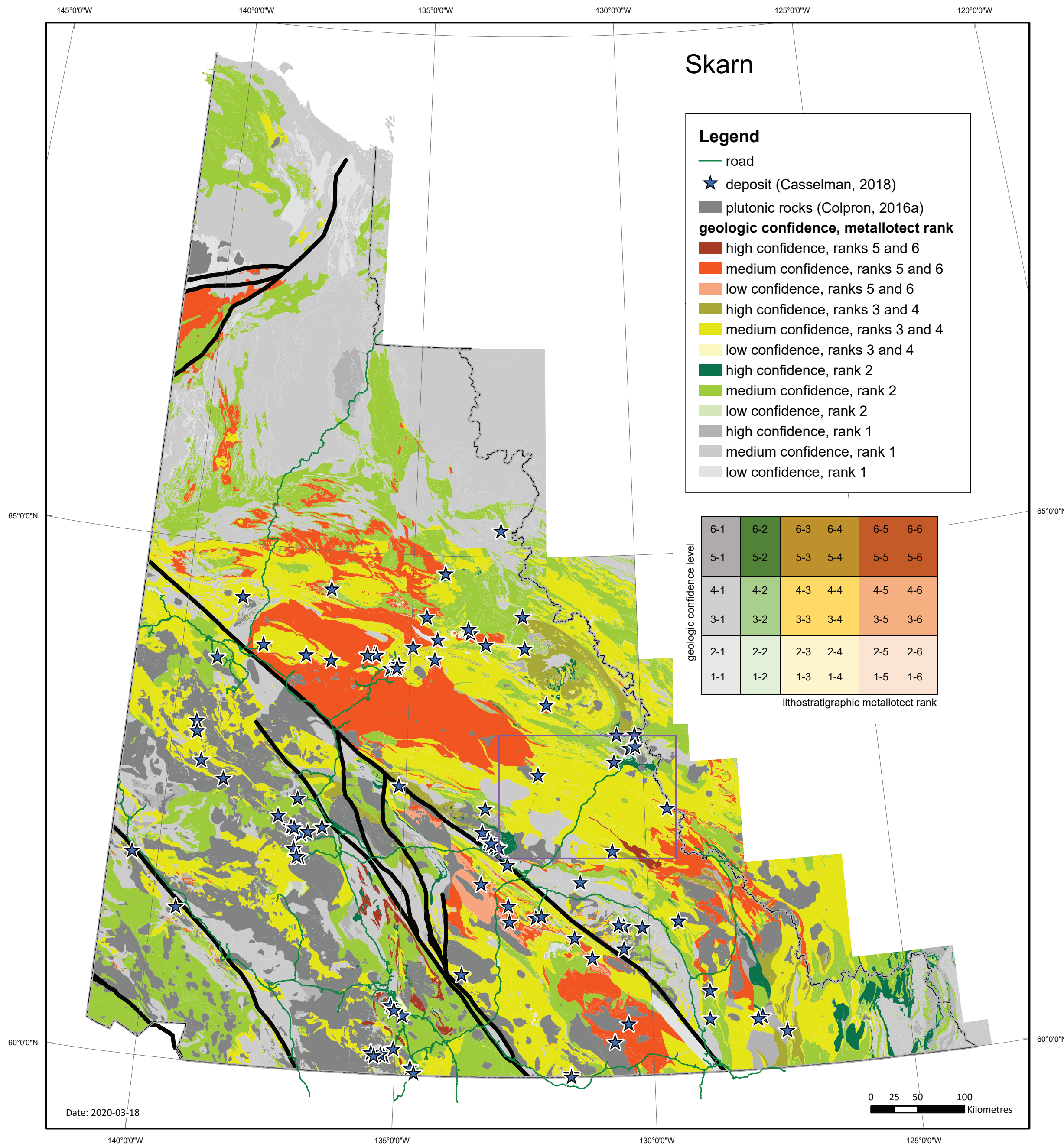


***Figure 16.*** *Skarn deposit-type metallotect map. Suitable rocks occur predominantly on the north side of the Tintina fault. The occurrences are coincident with Cretaceous plutonic rocks. Small intrusions, mappable at the property-scale, likely explain the presence of skarns where intrusions are not mapped regionally.*

## Further work and additional thoughts

The combined lithostratigraphic metallotect rank–geologic mapping confidence map may elucidate hitherto unknown information. In the maps presented in this report, lithologic suitability is the primary driver of metallotect rank. An alternative to this methodology would be to increase the weight given to mineral occurrence compatibility. For example, using the skarn deposit model, rank 3 represents the presence of skarn occurrences in a lithostratigraphic metallotect combination that is not particularly lithologically suitable to skarn mineralization. This may be due to the local presence of calcareous rocks that form a minor component in the map unit at a regional scale or intrusive rocks not shown on regional maps. If the presence of skarn mineral occurrences is consistent, increasing the 'weight' of these occurrences results in an alternative colour coding (*e.g.*, Fig. 17 and Table 9) that highlights the presence of skarn mineral occurrences despite being hosted in a lithologically poor regional map unit. Table 9 illustrates an example of combining ranks to give additional 'weight' to mineral occurrences compared to lithologic suitability. Plutonic rocks (not studied in this report) and rank 1 are coloured in grey. Rank 1 represents rocks that are not compatible with the skarn deposit type. As a corollary, the MINFILE occurrence compatibility is low. Ranks 2 and 4, coloured respectively in green and yellow, are lithostratigraphic metallotect combinations sharing a common low MINFILE occurrence compatibility but distinct lithologic suitability. Ranks 3, 5, and 6 represent lithostratigraphic metallotect combinations with a high MINFILE occurrence compatibility. It is important to remember that both mineral occurrences and bedrock geology are sources of data and the resulting lithostratigraphic metallotect rankings are interpretations to be considered carefully.

***Table 9.*** *Combined geologic confidence–lithostratigraphic metallotect rank chart used for Fig. 17(b). The first number corresponds to the geologic confidence; the second number corresponds to the occurrence confidence. The presence of an occurrence is considered to be more favorable than rock suitability.*

| | | | | | |
|---|---|---|---|---|---|
| 6-1 | 6-2 | 6-3 | 6-4 | 6-5 | 6-6 |
| 5-1 | 5-2 | 5-3 | 5-4 | 5-5 | 5-6 |
| 4-1 | 4-2 | 4-3 | 4-4 | 4-5 | 4-6 |
| 3-1 | 3-2 | 3-3 | 3-4 | 3-5 | 3-6 |
| 2-1 | 2-2 | 2-3 | 2-4 | 2-5 | 2-6 |
| 1-1 | 1-2 | 1-3 | 1-4 | 1-5 | 1-6 |

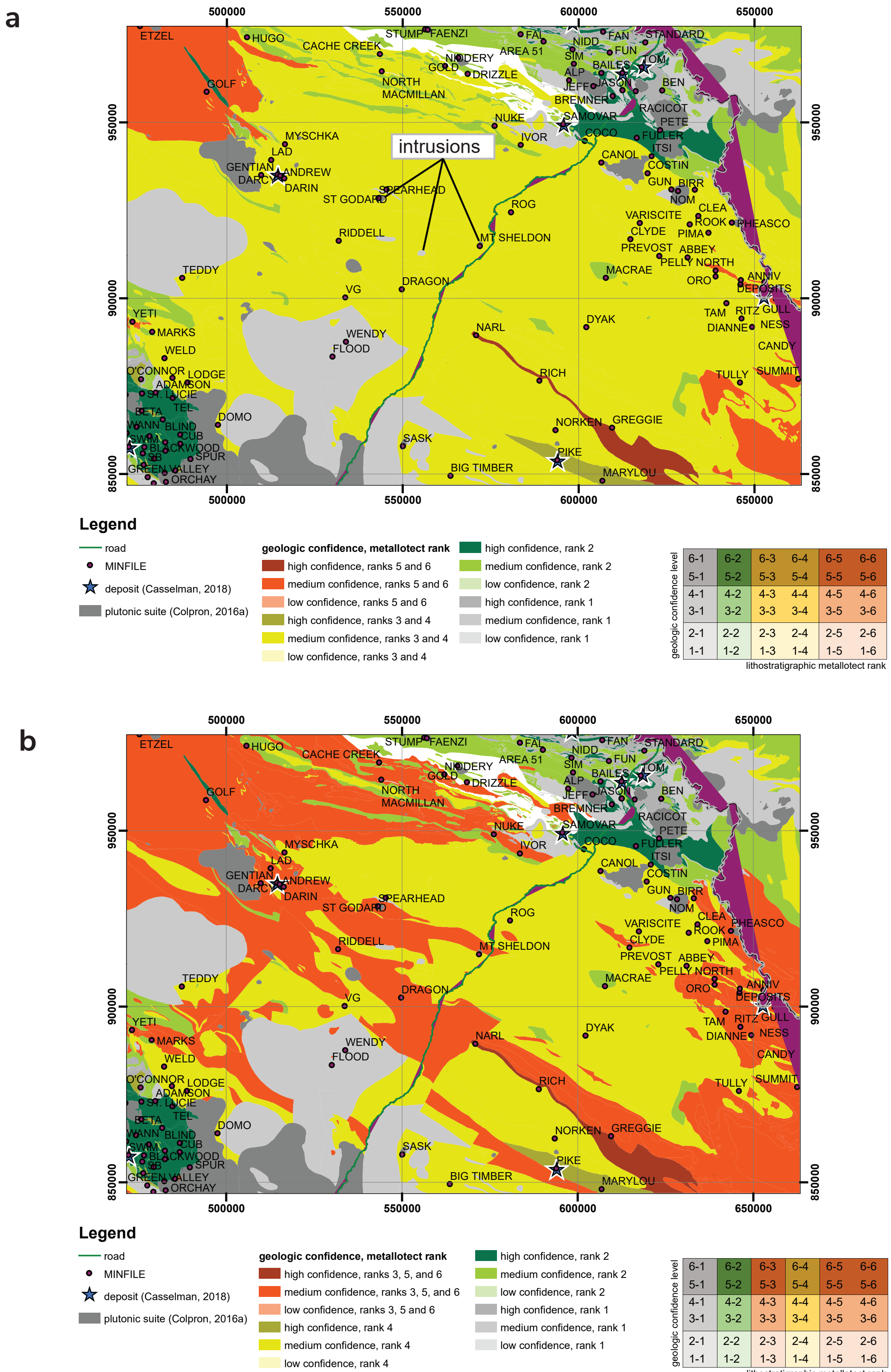


***Figure 17.*** *Example of different methods for colour coding geologic confidence–lithostratigraphic metallotect rank combinations for the skarn deposit type. (a) Metallotect rank driven primarily by lithologic suitability as used in Figures 5–16. (b) Alternative metallotect rank methodology driven primarily by presence of occurrences.*

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