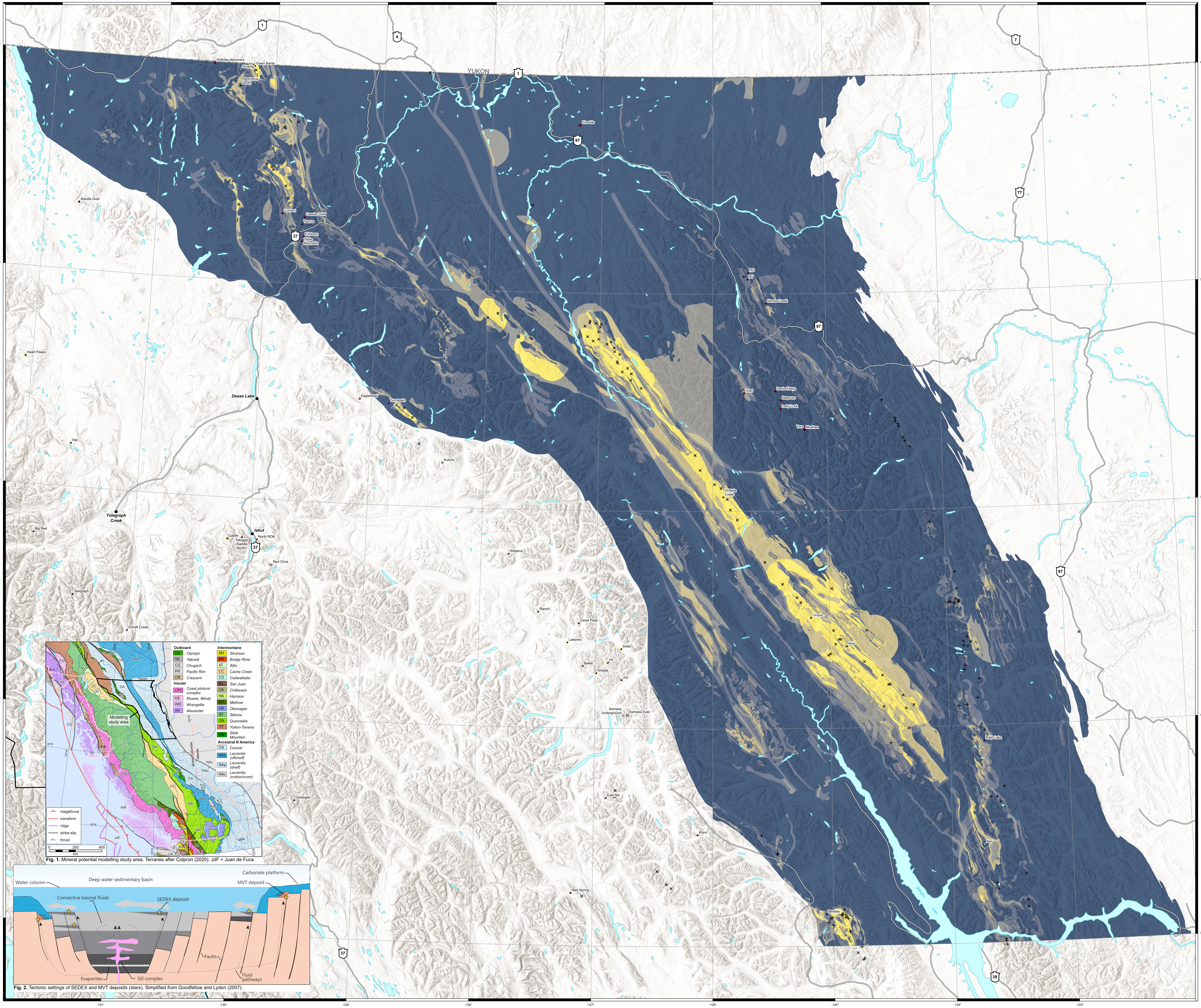

Fig. 1. Mineral potential modelling study area. Terranes after Colpron (2020). JdF = Juan de Fuca

Fig. 2. Tectonic settings of SEDEX and MVT deposits (stars). Simplified from Goodfellow and Lydon (2007).

Ministry of Energy, Mines and Low Carbon Innovation

Sheet 1: Preliminary mineral potential map for the sedimentary exhalative (SEDEX) mineral system, northeastern British Columbia

British Columbia Geological Survey
Open File 2024-11

Wearmouth, C.D., Czertowicz, T.A., and Peters, K.J.

Recommended citation: Wearmouth, C.D., Czertowicz, T.A., and Peters, K.J., 2024. Preliminary mineral potential maps for the SEDEX and MVT mineral systems, northeastern British Columbia. British Columbia Ministry of Energy, Mines and Low Carbon Innovation, British Columbia Geological Survey Open File 2024-11, 1:500,000 scale.

Scale: 1:500,000

0 25 50 75 100
Kilometres

Sheet 1 of 3

SEDEX mineral potential
- Highest
- High
- Moderate
- Low
- Lowest

Major projects

Mines
- Mine porphyry
- Mine epithermal
- Mine vein, breccia, and stockwork
- Mine development vein, breccia, and stockwork
- Past producer porphyry
- Temporary mine shutdown

Proposed mines
- Proposed mine porphyry
- Proposed mine vein, breccia, and stockwork
- Proposed mine marine volcanic association
- Proposed mine carbonatites

Selected exploration projects
- Porphyry
- Epithermal
- Vein, breccia, and stockwork
- Marine volcanic association
- Ultramafic/mafic
- Manto
- Mississippi Valley-type
- Sedimentary exhalative

Mineral occurrence
- Mississippi Valley-type
- Sedimentary exhalative

- Towns
- Roads

Marginal notes: Preliminary mineral potential map for the sedimentary exhalative (SEDEX) mineral systems in northeastern British Columbia – sheet 1 of 3

The British Columbia Geological Survey is revitalizing mineral potential mapping after nearly 30 years. This modelling uses data from bedrock mapping since the 1990s and integrates new discoveries, advanced exploration methods, and improved knowledge of geological processes. Furthermore, increased computing power during the past three decades has boosted the use of GIS platforms and statistical methods for mineral potential modelling. The current work uses a mineral systems approach, which focusses on the similarities between different deposits. This approach considers all the factors involved in creating and preserving deposits (source, transport, trap, and deposition). Herein we apply the weights of evidence method (Bonham-Carter et al., 1990; Bonham-Carter, 1994) for statistical spatial analysis of numerous mappable indicators (e.g., proximity to intrusive rock contacts, fault intersection density, stream-sediment geochemical anomalies, magnetic anomalies) to model the mineral potential for sedimentary exhalative (SEDEX) mineral system in a large area of northeastern British Columbia (Fig. 1). The study region encompasses the lands and traditional territories of many Indigenous rights holders, and this new mineral potential modeling will support decision-making and land-use planning. As society emphasizes a shift towards a low-carbon future, there will be an increased demand for minerals crucial for energy generation, storage, and transmission. This new modeling supports the search for both common critical elements like copper and ancillary 'companion' critical elements (Mudd et al., 2014) that were previously considered uneconomic or insignificant (Hickin et al., 2023, 2024). This release presents mineral potential modelling maps for the sedimentary exhalative mineral system (Sheet 1) illustrating the relative prospectivity of primary and companion commodities. Wearmouth et al. (2024a) discuss the methods employed in this current modelling, Wearmouth et al. (2024b) compare the results with modelling done by the British Columbia Geological Survey in the 1990s, and Wearmouth et al. (2024c) provide mineral potential maps for a large area in northwestern British Columbia.

The study region spans a large part of the northeastern Canadian Cordillera, a 2,000 km long mountainous belt comprising multiple far-traveled crustal slices or terranes, some having journeyed thousands of kilometers, to weld with the western margin of Ancestral North America in the last 180 million years (e.g., Nelson et al., 2013; Colpron and Nelson, 2021). The Cordillera chronicles a history of supercontinent breakup and rifting, beginning around 800 million years ago, and encompasses a series of oceanic island arc volcanosedimentary assemblages and related intrusive bodies that developed outboard of the rifted continental margin and accreted to each other and the continental margin. Terrane evolution persists today as the Juan de Fuca oceanic plate subducts (slides beneath) Vancouver Island. As reviewed by Nelson et al. (2013), Hickin et al. (2017), and Colpron and Nelson (2021), the varied tectonic processes from supercontinent breakup and arc terrane development to terrane accretion and subsequent magmatism, metamorphism, deformation, and sedimentation have produced a wide array of mineral systems across the province.

Current exploration in the modelling area, which includes parts of the Northeast and North Central mining regions, is active at numerous deposits (see summary in Clarke et al., 2024a, and map by Clarke et al., 2024b). The Northeast Region is prospective for coal and industrial minerals and, in 2023, had three producing coal mines: Brule, Wolverine, and Willow Creek (Conuma Resources Limited). Fireside Minerals Ltd. produces barite from its Fireside mine, SEDEX mineralization is being explored for at the Cirque deposit, at the Akie project, which includes the Cardiac Creek deposit, and at the Kechika North project.

The primary metals in SEDEX deposits are Pb and Zn (±Ag, Ge, In); some have a spatial association with stratiform barite deposits. SEDEX deposits, such as the historic Pb-Zn-Ag Sullivan mine, typically form in deep-water, off-shelf settings coeval with background sedimentation of fine-grained argillaceous material (Fig. 2). In 'vent-proximal' deposits, sulphide minerals grow near hydrothermal seafloor vents surrounded by fine-grained sediments. 'Vent-distal' deposits lack an apparent relationship to hydrothermal vents entirely and display a stratiform geometry with alternating sulphide rich and fine-grained interlayers (e.g., Goodfellow and Lydon, 2007; Sangster, 2018). SEDEX deposits represent the syndepositional accumulation of sulphide minerals derived from waters that have circulated through underlying basement rocks and the sedimentary pile and ascended to the sediment-water interface or close to it.

The mineral potential modelling comes with several caveats. First, the maps represent relative ranking of prospectivity rather than an absolute measure of the probability of finding a deposit. This is because the geological features that are used as proxies are not strictly independent; given that these features are commonly interrelated and influence one another, probabilities are likely overestimated. Second, mineral potential evaluations have uncertainties related to data availability, data quality, the level of correlation between mineral occurrences and the input data, the estimation method, and the deposit model that are partly cumulative. Because of these uncertainties, the potential assessments cannot be used to indicate the size or economics of a potential mineral deposit and cannot be used to make valuations on any resource. Third, any modelling is limited by the data available at any given time and thus the results represent a time-specific evaluation (Ford et al., 2019). For example, areas with a very low mineral potential ranking may merely reflect a paucity of data. In addition, the MINFILE database, which was used as an important source of spatial data, may not be entirely comprehensive. Older records continue to be revised and some critical minerals are likely underreported because they were not historically considered by the exploration community or because past analytical technology may have been inadequate to test for some elements. Future iterations may consider additional datasets or advancements in mineral system research, which may affect the results. Fourth, the prospectivity thresholds rankings purposed here, 'lowest, low, moderate, high, and highest' are based on five percentile divisions of the posterior probabilities for the mineral potential models. Importantly, the use of percentiles to arbitrarily define prospectivity thresholds is one of many methods (e.g., natural breaks, equal area binning, and custom binning) that can be used to define thresholds of prospectivity. Therefore, using another method to define prospectivity thresholds may not lead to the same conclusions derived in this study. Finally, the current maps only consider two mineral systems, and the relative prospectivity portrayed on the combined mineral potential map may change markedly as additional mineral systems are considered.

Acknowledgments

We thank Fil Ferri, JoAnne Nelson, and Luke Ootes for providing valuable feedback on the maps results. Special thanks to Paulina Marczak for GIS support and map production.

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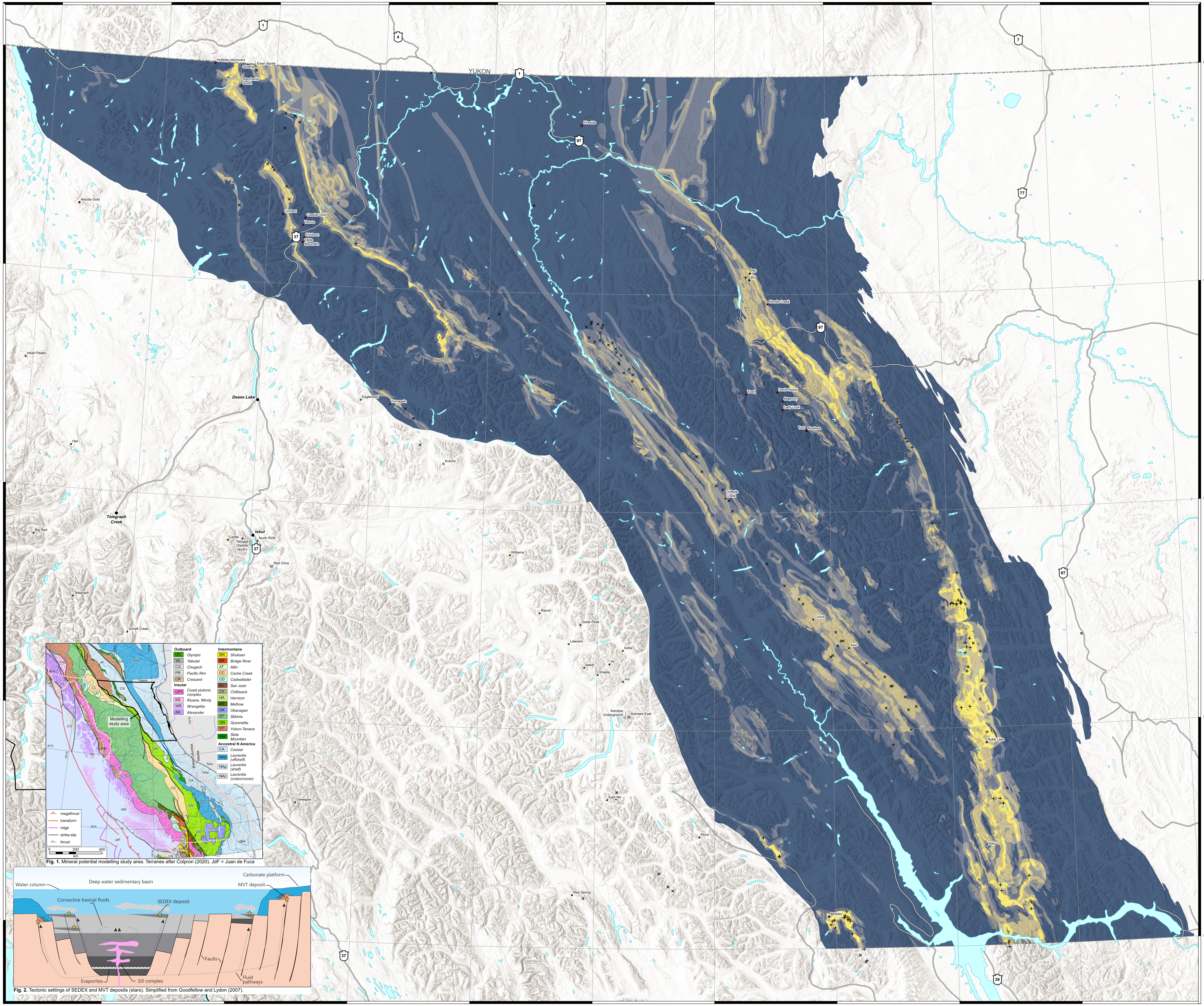

Fig. 1. Mineral potential modelling study area. Terranes after Colpron (2020). JdF = Juan de Fuca

Fig. 2. Tectonic settings of SEDEX and MVT deposits (stars). Simplified from Goodfellow and Lydon (2007).

Ministry of Energy, Mines and Low Carbon Innovation

Sheet 2: Preliminary mineral potential map for the Mississippi Valley-type (MVT) mineral system, northeast British Columbia

British Columbia Geological Survey
Open File 2024-11

Wearmouth, C.D., Czertowicz, T.A., and Peters, K.J.

Recommended citation: Wearmouth, C.D., Czertowicz, T.A., and Peters, K.J., 2024. Preliminary mineral potential map for the SEDEX and MVT mineral systems, northeast British Columbia. British Columbia Ministry of Energy, Mines and Low Carbon Innovation, British Columbia Geological Survey Open File 2024-11, 1:500,000 scale.

Scale: 1:500,000

0 25 50 75 100
Kilometres

Sheet 2 of 3

MVT mineral potential
- Highest
- High
- Moderate
- Low
- Lowest

Major projects

Mines
- Mine porphyry
- Mine epithermal
- Mine vein, breccia, and stockwork
- Mine development vein, breccia, and stockwork
- Past producer porphyry
- Temporary mine shutdown

Proposed mines
- Proposed mine porphyry
- Proposed mine vein, breccia, and stockwork
- Proposed mine marine volcanic association
- Proposed mine carbonatites

Selected exploration projects
- Porphyry
- Epithermal
- Vein, breccia, and stockwork
- Marine volcanic association
- Ultramafic/mafic
- Manto
- Mississippi Valley-type
- Sedimentary exhalative

Mineral occurrence
- Mississippi Valley-type
- Sedimentary exhalative

- Towns
- Roads

Marginal notes: Preliminary mineral potential map for the Mississippi Valley (MVT) mineral systems in northeastern British Columbia – sheet 2 of 3

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The study region spans a large part of the northeastern Canadian Cordillera, a 2,000 km long mountainous belt comprising multiple far-traveled crustal slices or terranes, some having journeyed thousands of kilometers, to weld with the western margin of Ancestral North America in the last 180 million years (e.g., Nelson et al., 2013; Colpron and Nelson, 2021). The Cordillera chronicles a history of supercontinent breakup and rifting, beginning around 800 million years ago, and encompasses a series of oceanic island arc volcanosedimentary assemblages and related intrusive bodies that developed outboard of the rifted continental margin and accreted to each other and the continental margin. Terrane evolution persists today as the Juan de Fuca oceanic plate subducts (slides beneath) Vancouver Island. As reviewed by Nelson et al. (2013), Hickin et al. (2017), and Colpron and Nelson (2021), the varied tectonic processes from supercontinent breakup and arc terrane development to terrane accretion and subsequent magmatism, metamorphism, deformation, and sedimentation have produced a wide array of mineral systems across the province.

Current exploration in the modelling area, which includes parts of the Northeast and North Central mining regions, is active at numerous deposits (see summary in Clarke et al., 2024a, and map by Clarke et al., 2024b). The Northeast Region is prospective for coal and industrial minerals and, in 2023, had three producing coal mines: Brule, Wolverine, and Willow Creek (Conuma Resources Limited). Fireside Minerals Ltd. produces barite from its Fireside mine and the Robb Lake MVT deposit is in early stages of exploration.

Like SEDEX deposits, MVT deposits represent the syndepositional accumulation of sulphide minerals derived from waters that have circulated through underlying basement rocks and the sedimentary pile and ascended to the sediment-water interface or close to it. Lead and Zn are the primary metals in MVT deposits but some have potential to contain Mg, Ga, Ge, In, REE, and F. In contrast to the typical deep-water setting of SEDEX deposits, MVT deposits are hosted by relatively shallow-water platformal carbonate successions (Fig. 2) in which both penecontemporaneous dolomitization of original calcium carbonate sediment and karst processes create void spaces for the precipitation of base-metal sulphides from low-temperature hydrothermal fluids to form stratabound epigenetic deposits (e.g., Sangster, 1990; Paradis et al., 2007).

The mineral potential modelling comes with several caveats. First, the maps represent relative ranking of prospectivity rather than an absolute measure of the probability of finding a deposit. This is because the geological features that are used as proxies are not strictly independent; given that these features are commonly interrelated and influence one another, probabilities are likely overestimated. Second, mineral potential evaluations have uncertainties related to data availability, data quality, the level of correlation between mineral occurrences and the input data, the estimation method, and the deposit model that are partly cumulative. Because of these uncertainties, the potential assessments cannot be used to indicate the size or economics of a potential mineral deposit and cannot be used to make valuations on any resource. Third, any modelling is limited by the data available at any given time and thus the results represent a time-specific evaluation (Ford et al., 2019). For example, areas with a very low mineral potential ranking may merely reflect a paucity of data. In addition, the MINFILE database, which was used as an important source of spatial data, may not be entirely comprehensive. Older records continue to be revised and some critical minerals are likely underreported because they were not historically considered by the exploration community or because past analytical technology may have been inadequate to test for some elements. Future iterations may consider additional datasets or advancements in mineral system research, which may affect the results. Fourth, the prospectivity thresholds rankings purposed here, 'lowest, low, moderate, high, and highest' are based on five percentile divisions of the posterior probabilities for the mineral potential models. Importantly, the use of percentiles to arbitrarily define prospectivity thresholds is one of many methods (e.g., natural breaks, equal area binning, and custom binning) that can be used to define thresholds of prospectivity. Therefore, using another method to define prospectivity thresholds may not lead to the same conclusions derived in this study. Finally, the current maps only consider two mineral systems, and the relative prospectivity portrayed on the combined mineral potential map may change markedly as additional mineral systems are considered.

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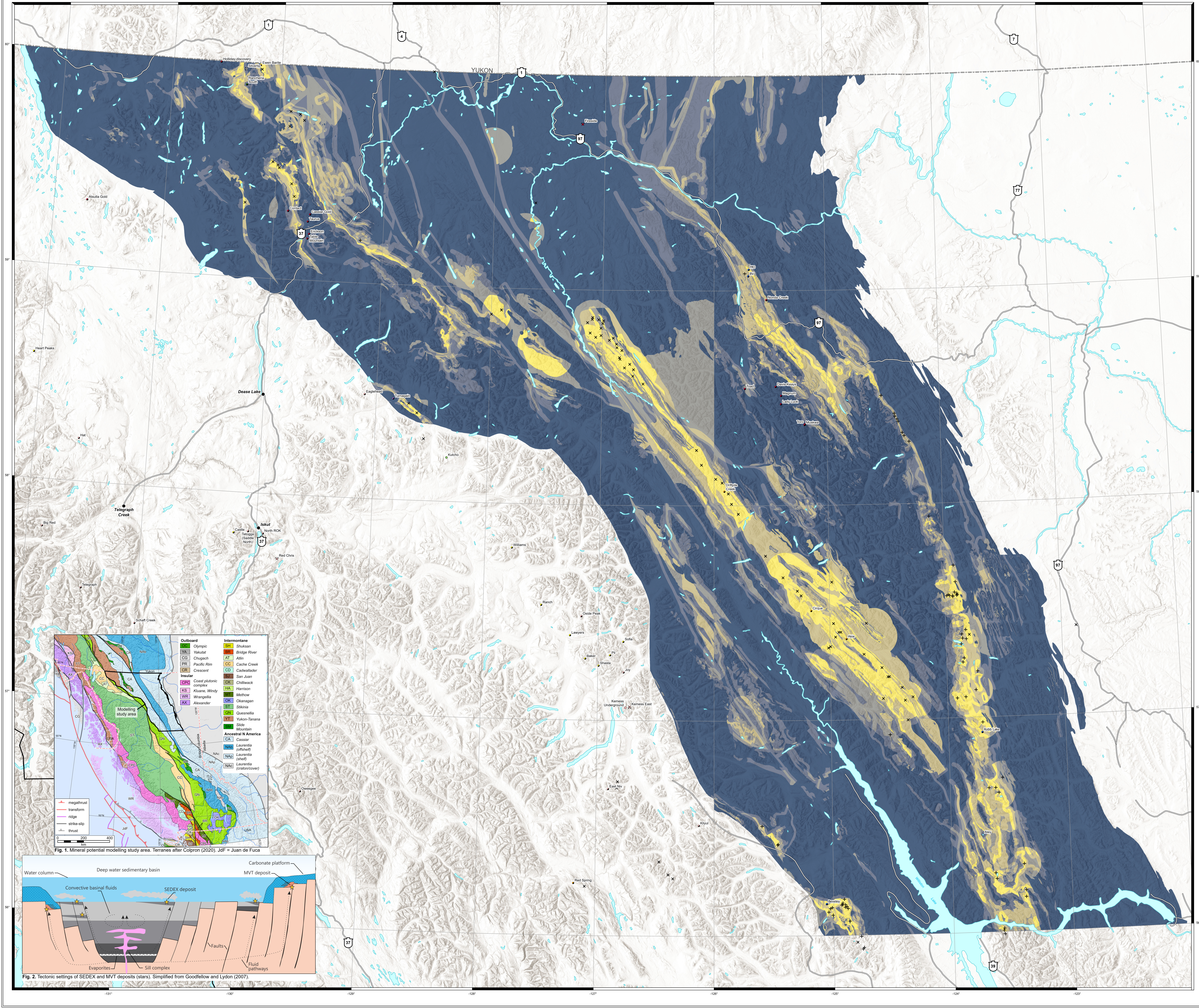

Fig. 1. Mineral potential modelling study area. Terranes after Colpron (2020). JdF = Juan de Fuca

Fig. 2. Tectonic settings of SEDEX and MVT deposits (stars). Simplified from Goodfellow and Lydon (2007).

Sheet 3: Preliminary mineral potential map for the combined SEDEX and MVT mineral systems, northeast British Columbia

British Columbia Geological Survey
Open File 2024-11

Wearmouth, C.D., Czertowicz, T.A., and Peters, K.J.

Recommended citation: Wearmouth, C.D., Czertowicz, T.A, and Peters, K.J., 2024. Preliminary mineral potential maps for the SEDEX and MVT mineral systems, northeastern British Columbia. British Columbia Ministry of Energy, Mines and Low Carbon Innovation, British Columbia Geological Survey Open File 2024-11, 1:500,000 scale.

Scale: 1:500,000

0 25 50 75 100
Kilometres

Sheet 3 of 3

Combined SEDEX and MVT mineral potential
- Highest
- High
- Moderate
- Low
- Lowest

Major projects

Mines
- Mine porphyry
- Mine epithermal
- Mine vein, breccia, and stockwork
- Mine development vein, breccia, and stockwork
- Past producer porphyry
- Temporary mine shutdown

Proposed mines
- Proposed mine porphyry
- Proposed mine vein, breccia, and stockwork
- Proposed mine marine volcanic association
- Proposed mine carbonatites

Selected exploration projects
- Porphyry
- Epithermal
- Vein, breccia, and stockwork
- Marine volcanic association
- Ultramafic/mafic
- Manto
- Mississippi Valley-type
- Sedimentary exhalative

Mineral occurrence
- Mississippi Valley-type
- Sedimentary exhalative

- Towns
- Roads

Marginal notes: Preliminary mineral potential map for the combined sedimentary exhalative (SEDEX) and Mississippi Valley-type (MVT) mineral systems in northeastern British Columbia – sheet 3 of 3

The British Columbia Geological Survey is revitalizing mineral potential mapping after nearly 30 years. This modelling uses data from bedrock mapping since the 1990s and integrates new discoveries, advanced exploration methods, and improved knowledge of geological processes. Furthermore, increased computing power during the past three decades has boosted the use of GIS platforms and statistical methods for mineral potential modelling. The current work uses a mineral systems approach, which focusses on the similarities between different deposits. This approach considers all the factors involved in creating and preserving deposits (source, transport, trap, and deposition). Herein we apply the weights of evidence method (Bonham-Carter et al., 1990; Bonham-Carter, 1994) for statistical spatial analysis of numerous mappable indicators (e.g., proximity to intrusive rock contacts, fault intersection density, stream-sediment geochemical anomalies, magnetic anomalies) to model the mineral potential for sedimentary exhalative (SEDEX) and Mississippi Valley-type (MVT) mineral systems in a large area of northeastern British Columbia (Fig. 1). The study region encompasses the lands and traditional territories of many Indigenous rights holders, and this new mineral potential modeling will support decision-making and land-use planning. As society emphasizes a shift towards a low-carbon future, there will be an increased demand for minerals crucial for energy generation, storage, and transmission. This new modeling supports the search for both common critical elements like copper and ancillary 'companion' critical elements (Mudd et al., 2014) that were previously considered uneconomic or insignificant (Hickin et al., 2023, 2024). This release presents mineral potential modelling maps for the sedimentary exhalative mineral system (Sheet 1), the Mississippi Valley-type system (Sheet 2), and a combined map of both systems (Sheet 3), illustrating the relative prospectivity of primary and companion commodities. Wearmouth et al. (2024a) discuss the methods employed in this current modelling, Wearmouth et al. (2024b) compare the results with modelling done by the British Columbia Geological Survey in the 1990s, and Wearmouth et al. (2024c) provide mineral potential maps for a large area in northwestern British Columbia.

The study region spans a large part of the northeastern Canadian Cordillera, a 2,000 km long mountainous belt comprising multiple far-traveled crustal slices or terranes, some having journeyed thousands of kilometers, to weld with the western margin of Ancestral North America in the last 180 million years (e.g., Nelson et al., 2013; Colpron and Nelson, 2021). The Cordillera chronicles a history of supercontinent breakup and rifting, beginning around 800 million years ago, and encompasses a series of oceanic island arc volcanosedimentary assemblages and related intrusive bodies that developed outboard of the rifted continental margin and accreted to each other and the continental margin. Terrane evolution persists today as the Juan de Fuca oceanic plate subducts (slides beneath) Vancouver Island. As reviewed by Nelson et al. (2013), Hickin et al. (2017), and Colpron and Nelson (2021), the varied tectonic processes from supercontinent breakup and arc terrane development to terrane accretion and subsequent magmatism, metamorphism, deformation, and sedimentation have produced a wide array of mineral systems across the province.

Current exploration in the modelling area, which includes parts of the Northeast and North Central mining regions, is active at numerous deposits (see summary in Clarke et al., 2024a, and map by Clarke et al., 2024b). The Northeast Region is prospective for coal and industrial minerals. Fireside Minerals Ltd. produces barite from its Fireside mine, SEDEX mineralization is being explored for at the Cirque deposit, and at the Akie project, and the Robb Lake MVT deposit is in early stages of exploration.

The primary metals in SEDEX deposits are Pb and Zn (±Ag, Ge, In); some have a spatial association with stratiform barite deposits. SEDEX deposits, such as the historic Pb-Zn-Ag Sullivan mine, typically form in deep-water, off-shelf settings coeval with background sedimentation of fine-grained argillaceous material (Fig. 2). In 'vent-proximal' deposits, sulphide minerals grow near hydrothermal seafloor vents surrounded by fine-grained sediments. 'Vent-distal' deposits lack an apparent relationship to hydrothermal vents entirely and display a stratiform geometry with alternating sulphide rich and fine-grained interlayers (e.g., Goodfellow and Lydon, 2007; Sangster, 2018). Both represent the syndepositional accumulation of sulphide minerals derived from waters that have circulated through underlying basement rocks and the sedimentary pile and ascended to the sediment-water interface or close to it.

Lead and Zn are the primary metals in MVT deposits but some have potential to contain Mg, Ga, Ge, In, REE, and F. In contrast to the typical deep-water setting of SEDEX deposits, MVT deposits are hosted by relatively shallow-water platformal carbonate successions (Fig. 2) in which both penecontemporaneous dolomitization of original calcium carbonate sediment and karst processes create void spaces for the precipitation of base-metal sulphides from low-temperature hydrothermal fluids to form stratabound epigenetic deposits (e.g., Sangster, 1990; Paradis et al., 2007).

The mineral potential modelling comes with several caveats. First, the maps represent relative ranking of prospectivity rather than an absolute measure of the probability of finding a deposit. This is because the geological features that are used as proxies are not strictly independent; given that these features are commonly interrelated and influence one another, probabilities are likely overestimated. Second, mineral potential evaluations have uncertainties related to data availability, data quality, the level of correlation between mineral occurrences and the input data, the estimation method, and the deposit model that are partly cumulative. Because of these uncertainties, the potential assessments cannot be used to indicate the size or economics of a potential mineral deposit and cannot be used to make valuations on any resource. Third, any modelling is limited by the data available at any given time and thus the results represent a time-specific evaluation (Ford et al., 2019). For example, areas with a very low mineral potential ranking may merely reflect a paucity of data. In addition, the MINFILE database, which was used as an important source of spatial data, may not be entirely comprehensive. Older records continue to be revised and some critical minerals are likely underreported because they were not historically considered by the exploration community or because past analytical technology may have been inadequate to test for some elements. Future iterations may consider additional datasets or advancements in mineral system research, which may affect the results. Fourth, the prospectivity thresholds rankings purposed here, 'lowest, low, moderate, high, and highest' are based on five percentile divisions of the posterior probabilities for the mineral potential models.

Importantly, the use of percentiles to arbitrarily define prospectivity thresholds is one of many methods (e.g., natural breaks, equal area binning, and custom binning) that can be used to define thresholds of prospectivity. Therefore, using another method to define prospectivity thresholds may not lead to the same conclusions derived in this study. Finally, the current maps only consider two mineral systems, and the relative prospectivity portrayed on the combined mineral potential map may change markedly as additional mineral systems are considered.

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