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KIMBERLITES OF THE CORONATION GULF FIELD, NORTHERN SLAVE CRATON, NUNAVUT CANADA

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INTRODUCTION

The Coronation Gulf kimberlites have intruded into Archean-aged rocks of the northern Slave Craton and in certain instances, the overlying and onlapping sedimentary rocks of the Paleoproterozoic Wopmay Orogeny. The area is host to approximately 26 known kimberlites, several of which are recognized to be enriched in diamond (10 to 46 carats per hundred tonne) and a number are poorly diamondiferous to barren. The field is characterized by two types of intrusions, hypabyssal and volcaniclastic kimberlites which may form pipes, dykes, sills, and irregular shaped plugs. Kimberlites within the field host one of two distinct heavy mineral populations, one dominated by oxide minerals and the second with a silicate-oxide signature. Intrusions that host the silicate (gnt-cpx-ol-ilm-sp) signature typically contain more significant diamond contents then those bodies which are dominated by the oxides (i.e. Mg-ilmenite). Volcaniclastic pipes were emplaced at ca. 616 Ma and the hypabyssal intrusions have multiple emplacement ages ranging from ca. 600 to 520 Ma. Intrusions within the known extents of the Coronation field may be subdivided into several groupings on the basis of: mantle signature, diamond tenor, emplacement age, pipe/intrusion geology, whole rock geochemistry and groundmass mineral chemistry.

BEDROCK GEOLOGY

The known extent of the Coronation Gulf kimberlite field (CGF) covers approximately 4,500 square kilometers and traverses the boundary between the Slave Craton to the east and rocks of the Wopmay Orogeny to the west, with the majority of kimberlites sitting within the Wopmay Orogen (Figure 1). Slave Craton rocks are comprised of ca. 2.7 Ga supracrustal rocks of the Yellowknife Supergroup, intruded by late Archean aged granitoids (2.65 – 2.55 Ga).

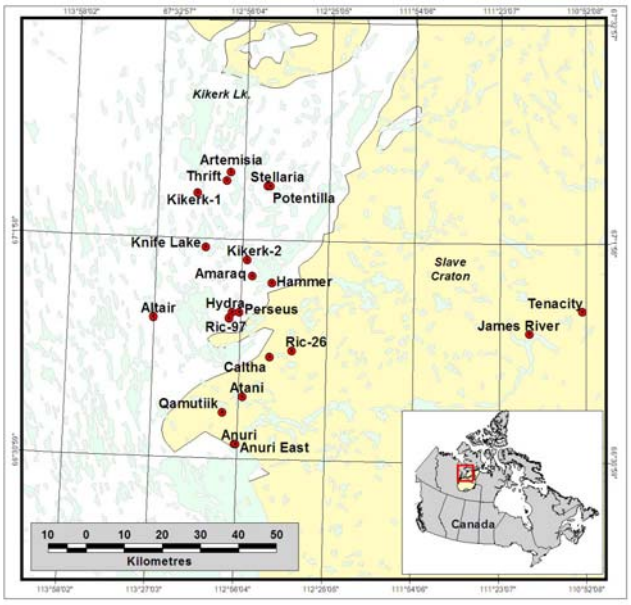

Figure 1. Location map of kimberlites within the Coronation Gulf region.

Shelf rise and fore-deep sediments of the Epworth and Recluse Groups of the Paleoproterozoic Coronation Supergroup underlie the western portion of the kimberlite field. The Epworth Group is further subdivided into the lower Odjick Formation dominated by siliciclastic rocks which are in turn overlain by stromatolitic dolomites and shales of the Rocknest Formation. The Epworth Group was deformed during the 1.90-1.88 Ma Calderian Orogeny and is overlain by flysch and molasse deposits of the Recluse Group, mainly comprised of turbidites, shales and siltstones (Bowring and Grotzinger, 1992). Multiple generation of diabase dykes and sills intrude both the Archean basement rocks and the overlying rocks of the Wopmay Orogeny. The north-northwest MacKenzie swarm (1.27 Ga) and northeast trending dykes and sills of the Franklin event (0.72 Ga) are the dominant intrusions although up to five

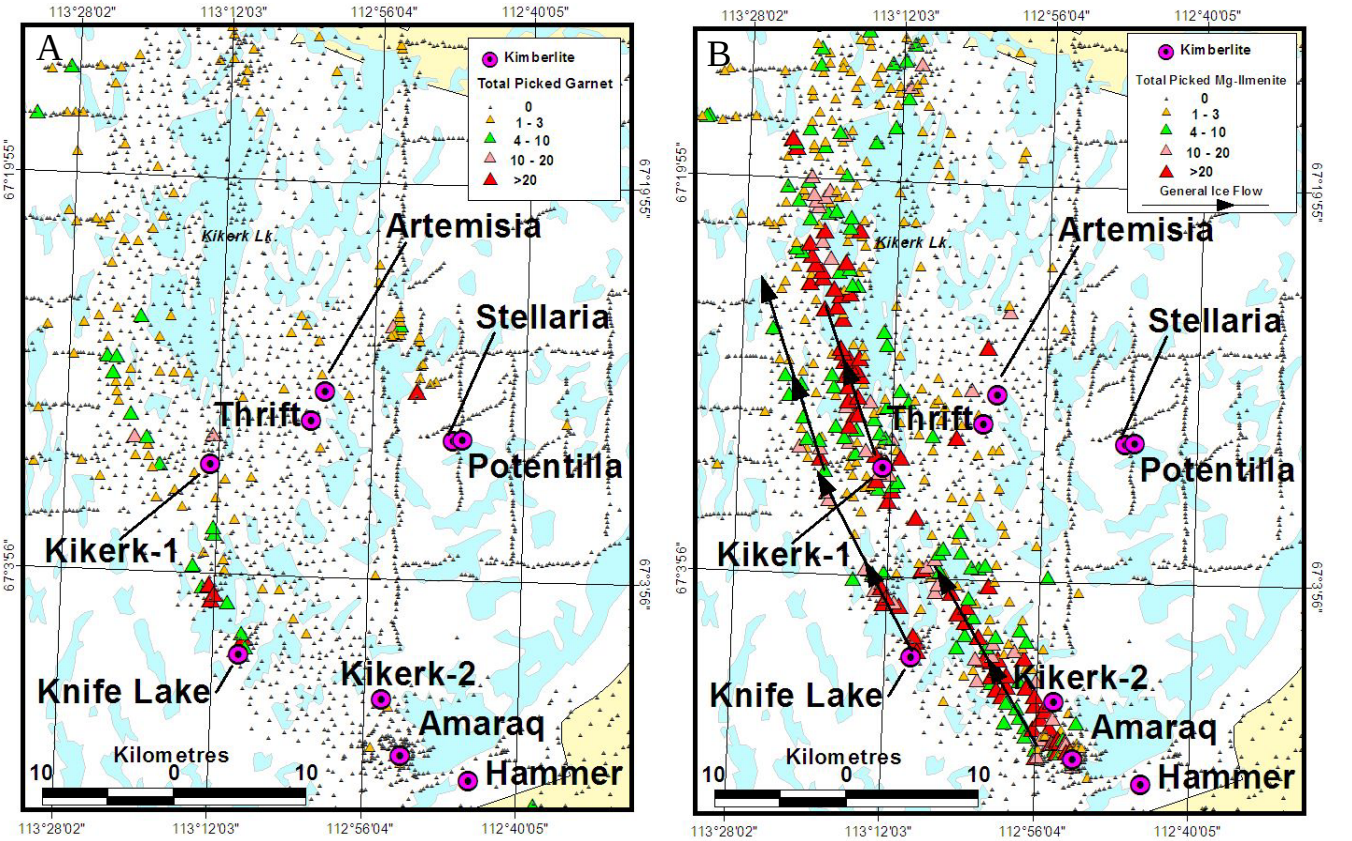

Figure 2. A) Total garnet grain counts, B) total Mg-ilmenite grains counts for the northern portion of the Coronation Gulf Kimberlite field. Garnet dispersions are associated with volcaniclastic (i.e. Knife Lake) and hypabyssal kimberlites (i.e. Potentilla/Stellaria) with diamond contents > 10cpht, Mg-ilmenite dominated trains are associated with barren hypabyssal intrusions (i.e. Kikerk-1, Thrift).

major (1.27-2.23 Ga) and two lesser (0.78 Ga and 0.72 Ga) dykes swarms are known in the north central portion of the Slave Craton (LeCheminant et al., 1996).

GLACIAL DISPERSION OF KIMBERLITE INDICATOR MINERALS

Multiple diamond exploration companies have conducted numerous tranches of exploration within the Coronation Gulf region since the early 1990's up until 2011, which has lead to the discovery of some 26 kimberlite intrusions. A key component of these programs was sampling of glacially derived sediments for kimberlite indicator minerals. A significant proportion of the resultant data was captured in government mandated industry assessment filings and subsequently compiled into digital formats (Armstrong, 2001; Armstrong and Chatman, 2001) enabling the study of regional glacial dispersions. Within the CGF region dispersion trains are linear in nature (Armstrong and Kjarsgaard, 2003; McClenaghan and Kjarsgaard, 2007) and overall indicator mineral abundances suggest the presence of significantly different source rocks. Dispersion plumes may measure up to 29 kilometres in length with widths of up to 8 kilometres, while other dispersions form narrower (<1 kilometre wide) sinuous plumes, as well relatively short (<3 kilometres in length) plumes are present. Ilmenite dominant trains are sourced from a number of intrusions (Kikerk-1, Kikerk-2, Perseus, RIC-97), and trains with more silicate dominant assemblages (lherzolitic and weak harzburgitic signatures) are sourced from the Artemisia, Potentilla, Stellaria, Hammer, and Knife Lake kimberlites (Figure 2a,b).

KIMBERLITE GEOLOGY

Examination of hand specimens, float samples, outcrops and re-logging of available drillcore for specific intrusions, has determined that two main kimberlite types are present within the CGF. Hypabyssal kimberlite may form dykes, sills, or pipe-like bodies and the larger pipes within the field are infilled with volcaniclastic kimberlite interpreted to represent pyroclastic deposits. Data for selected kimberlites is summarized in Table 1. Limited drill hole data does hamper three dimensional modeling of the occurrences.

Table 1: Coronation Gulf : Descriptive Details, Selected Kimberlites								Petrographic Summary							
Intrusion	Emplacement Age (Ma)	Country Rock	Kimberlite Type	Surface Expression (ha)	MacroDiamond Content (cpht)	GeoPhy	Dispersion Train	Ol (M)	Ol (Ph)	Ph (M)	Phl (ph/gm)	Pvk	Sp	Ap	Cc
Artemisia	616	Wopmay	VK	3	16	EM	p-gar, e-gar, chrm, ilm, cpx	**X** (alt)	**X** (alt)	x	x gm	x	x	x	x
Knife Lk		Wopmay	VK	10.2	20-25	Mag/EM	p-gar, e-gar, chrm, ilm, +/-cpx	**X** (alt)	**X** (alt)	X	X ph	x	x	x	x
Caltha		Slave	VK	6.2	barren	EM	ilm-sp-+/-pyr	x (alt)	**X** (alt)			x	x		x
Hammer		Slave	VK	0.4	tbd	Mag High	p-gar, e-gar, chrm, ilm, +/-cpx								
Potentilla		Wopmay	HK	4.8	18	Mag High	p-gar, e-gar, chrm, ilm, +/-cpx	**X** (alt/frh)	**X** (alt/frh)		x gm		x		
Stellaria		Wopmay	HK	dyke	micro enriched	Mag Linear	p-gar, e-gar, chrm, ilm, +/-cpx	**X** (alt)	**X** (alt)			x	x		x
Hydra	601	Wopmay	HK	sill	barren	Mag High	p-gar, chrm	x (alt)	**X**		X gm	x	x	x	x
Thrift	538	Wopmay	HK	ud	barren	Mag High	-	x (alt)	x (alt)		X gm	X	X	x	**X**
Kikerk-1	520	Wopmay	HK	ud	barren	Mag High	ilm +/- pyr	**x**	**X**		x gm	**X**	**X**	**x**	**x**
Perseus	534	Wopmay	UML/HK	sill	barren	Mag High	-	X	**x**		X	**X**	X	x	x

VK: Volcaniclastic, HK: Hypabyssal;UML: Ultramafic lamprophyre; tbd: to be determined

OL (M): olivine macrocryst; Ol (ph): Olivine phenocryst; Ph(M): phlogopite macrocryst; alt: altered; frh: fresh; gm: groundmass; ph:phenocryst; Pvk: perovskite; Sp: spinel; Ap: apatite; Cc: clacite; **X**>X>**x**>x

Volcaniclastic Kimberlite

A total of four volcaniclastic kimberlites have been identified in the immediate CGF: Artemisia, Caltha, Hammer and Knife Lake. Artemisia and Knife Lake have been subject of both micro and macrodiamond sampling, while Caltha has been subject to only microdiamond sampling. The Hammer kimberlite was drilled in the summer of 2011 and both micro and macro diamond sampling were conducted, although results are yet to be determined. The Artemisia kimberlite lies on the northern boundary of the CGF. The 3 hectare intrusion is a pyroclastic, crater-facies kimberlite, with three internal sub-units defined on the basis of mantle and crustal xenolith abundance and is described as a matrix-supported, olivine rich moderately sorted pyroclastic kimberlite. Two populations of olivine are observed, a medium grained, partially fresh population and a very fine grained typically serpentine-altered variety. Artemisia has yielded a U-Pb perovskite emplacement age of ca. 616 Ma. Within the east central portion of the CGF sits the Caltha intrusion. Caltha was discovered at the head of a prominent indicator mineral train at a break in a large regional scale NNW-trending diabase dyke, and is characterized by a strong EM resistivity low with a weak or no magnetic response. Caltha has a dual lobate geophysical character, however only one lobe was drill tested; the single lobe model is approximately 3.3 hectares in size, the dual lobe model generates a projected surface area of 6.2 hectares. Caltha geology is dominated by a loosely-packed, poorly-sorted, clast-supported green-grey pyroclastic kimberlite with five dominant textural varieties of juvenile clasts, including irregularly shaped and multiphase clasts. A hypabyssal unit is also present within the Caltha pipe. Toward the western portion of the CGF sits the Knife Lake pipe which was discovered in 2000 and lies at the intersection of a NW trending and E-W trending set of diabase dykes. With a surface area of 10.2 hectares Knife Lake represents one of the largest bodies within the CGF (Chisholm and Jamieson, 2006). The kimberlite is infilled by four dominant volcaniclastic rock types which represent separate eruptive events (Hetman et al., 2004; Chisholm and Jamieson, 2006). The Hammer kimberlite was discovered by prospecting in 2009 at the head of <2 kilometre long indicator dispersion train and drill tested in summer 2011. The intrusion sits south of the Tree River and immediately to the south of the Slave/Wopmay unconformity within the Slave Craton. The small, 0.4 hectare, intrusion forms two lobes infilled by two sub-units interpreted to represent a single phase. The intrusion is described as an olivine-rich, clast-supported, massive to weakly bedded, moderately-sorted, heterolithic pyroclastic kimberlite (Fitzgerald, 2011).

Hypabyssal Kimberlite

The CGF is host to a number of hypabyssal intrusions. The Stellaria and Potentilla intrusions lie on then NE edge of the CGF and display slightly different mantle signatures as compared to other CGF hypabyssal intrusions. The pipe-like Potentilla intrusion is a magnetic high feature, associated with a prominent indictor train and contains multiple phases of hypabyssal kimberlite (HK), hypabyssal kimberlite breccias (HKB), and a brecciated country rock halo. Two textural varieties of HKB are present, one characterized by altered olivine, and a second unit with more abundant carbonate in addition to the altered olivine. The Stellaria dyke was intersected in drillcore at the head of a prominent indicator train associated with a linear magnetic high response. Modeling of available drill data suggests that the dyke is sub-vertical with an apparent thickness of 8.5 metres. Fine grained HK with common carbonate segregations is the only kimberlite phase present in Stellaria. The Thrift HK intrusion is located approximately four kilometres to the southwest of Artemisia and is a dark grey to black, magnetic, carbonate rich intrusion which displays flow banding at the margin of the intrusion. U-Pb perovskite age dating of the Thrift has yielded an age determination of ca. 538 Ma. Southwest of Potentilla and Stellaria are the Kikerk-1 and Kikerk-2 HK intrusions that are typified by regionally significant ilmenite dominated glacial dispersions. The Kikerk -1 intrusion has yielded a U-Pb perovskite emplacement age of ca. 520 Ma. At least three phases of kimberlite are recognized from a macroscopic perspective at Kikerk-1: fine grained, fine grained with abundant carbonate, and a medium grained very ilmenite-rich unit.

The southern portion of the CGF hosts both HK pipe-like intrusions (RIC-97) and HK dykes/sills (Hydra, RIC-26, and Perseus). Hydra is a subcrop occurrence of dark grey kimberlite, with fine to very-fine grained serpentinised olivine macrocrysts set in a groundmass of carbonate, phlogopite, spinel, and fine carbonate segregations. U-Pb perovskite dating of the Hydra intrusion has yielded an emplacement age of ca. 601 Ma. RIC-97 is defined by prominent magnetic high feature. The intrusion consists of a dark grey kimberlite, with fine grained olivine variably altered to serpentine and common fine-grained carbonate segregations. Darker coloured, undiluted HK sheets with abundant carbonate veining are also observed. The Perseus sill dips at approximately 4º to the NE and differs from the other dyke and sill-like intrusions in that well developed chill margins are present. The interpreted chill margins are comprised of dark black aphanitic, mica-rich material with very fine grained serpentinised olivine and fine carbonate segregations. Internal to the chill margins the sill hosts a dark brown mica-rich phase with fine carbonate segregations in the groundmass and apparent flow banding. The core of the sill is host to a light green zone with fine grained serpentinised olivine and is significantly more carbonate rich. The Perseus intrusion yielded a U-Pb perovskite age of ca. 534Ma.

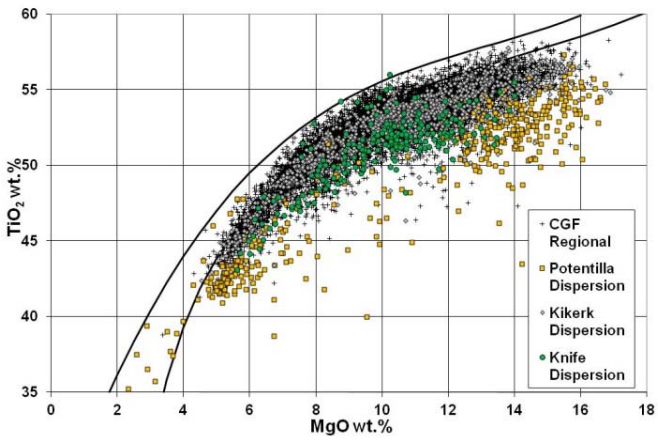

Figure 3. Mg-ilmenite chemistry for Coronation Gulf Kimberlite field glacial dispersions.

DIAMOND CONTENT

The majority of kimberlites within the CGF have been tested for microdiamonds, and based upon encouraging results several bodies have been subjected to additional testing for macro diamonds to determine diamond content/grade potential. Most kimberlites tested for microdiamonds returned very low counts, including the Caltha volcaniclastic intrusion. The Artemisia kimberlite returned a sample grade of 15 carats per hundred tonne (cpht) from a 96 tonne surface point source sample (Vaaldiam, 2007). A 7.5 tonne composite sample of the Knife Lake kimberlite returned a sample grade of 11 cpht (Chisholm and Jamieson, 2006). Grade modeling of Knife Lake kimberlite lithologies returned model grades of up to 31 cpht for specific units (Chisholm and Jamieson, 2006). A 5.8 tonne sample of Potentilla returned 1.02 carats for a sample grade of 17.5 cpht (+1.0mm; Ashton Mining, 2002) and diamond contents for individual units range from 8 to 46 cpht.

MINERAL CHEMISTRY

Kimberlite

Groundmass phlogopite data for the majority of the hypabyssal kimberlite bodies are consistent with world-wide examples of phlogopite from Archetypal (Group 1) kimberlites. Groundmass phlogopite within volcaniclastic kimberlites display rim chemistry consistent with increased alteration due to country rock contamination. Perseus groundmass phlogopite with tetraferriphlogopite rim compositions are indicative of a more ultramafic lamprophyre paragenesis for this intrusion, consistent with mapped features and bulk geochemical data.

Xenocrysts and Megacrysts

The availability of public domain datasets allows for comparison of both the silicate and oxide mineral signatures from different kimberlite sources (Armstrong, 2001; Armstrong and Chatman, 2001; Hetman et al., 2004). Regionally, ilmenite megacryst chemistry appears similar (Figure 3), although ilmenite is much more abundant in trains sourced from diamond-poor kimberlites. Data for garnet xenocrysts indicate that the CGF is dominated by a lherzolitic signature with maximum Cr_2O_3 contents of up to 12 wt. %. However, specific dispersion trains and intrusions host high Cr, subcalcic pyrope with a harzburgitic signature, but are not typically significantly CaO depleted. Minimum pressure estimations for the small subpopulation of harzburgitic garnets are in the range of 50-55 Kbar based upon Grütter et al. (2006). Garnet xenocryst signatures display subtle differences between till data from the Knife Lake and Potentilla kimberlites. The Potentilla data are offset to the right of the G9-G10 line and span the lherzolitic trend from 2 to 12 wt.% Cr_2O_3, several grains plot to the left of the line and are classified as G10's. There is a cluster of data with CaO contents of 4 to 6 wt.% and Cr_2O_3 contents of 2-4 wt.%, indicative of the megacryst garnet suite. The Knife Lake data also plots parallel to the G9-G10 line but lie closer to, and overlap the line with several analyses falling on the high Cr_20_3 side of the G9-G10 line (Figure 4). The Potentilla and Knife Lake kimberlites also contain garnets with eclogite signatures. Potentilla eclogite garnet is similar to that of Jericho, while the Knife Lake population contains a subset with Cr_2O_3 >0.1<2.0 wt.%, and CaO of 6 to 8 wt.% similar to

compositions reported for central Slave eclogite (Aulbach et al., 2007). Regional chromite data is defined by a significant proportion of grains with increasing TiO_2 contents with decreasing Cr_2O_3, indicative of phenocryst (magmatic) chromite. The xenocryst chromite population(< 0.07 wt.% Ti02) have maximum Cr_2O_3 contents of approximately 59 wt% Cr_2O_3, and diamond inclusion chromite compositions are rare in the CGF dataset.

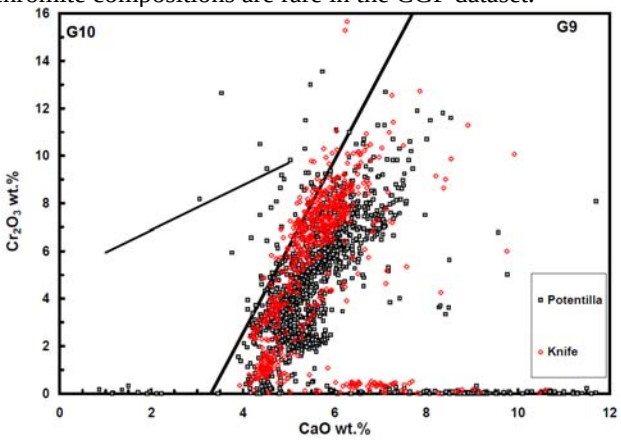

Figure 4. Garnet xenocryst and megacryst chemistry from down-ice till dispersions for the Knife Lake volcaniclastic and Potentilla hypabyssal kimberlites.

SUMMARY

Detailed rock descriptions, groundmass mineral chemistry and whole rock geochemistry indicate that the majority of the bodies within the CGF are consistent with world-wide Archetypal (Group 1) kimberlites. Neoproterozoic volcaniclastic kimberlites host a mantle sample defined by lherzolitic garnet, sub-ordinate harzburgitic garnet, eclogitic garnet, chromite, chrome diopside, and megacryst suite Cr-Ti garnet, and Mg-ilmenite. Hypabyssal intrusions (Potentilla, Stellaria) within the northern portion of the CGF host a mantle sample and diamond content similar to that of the volcaniclastic Artemisia and Knife Lake occurrences. Diamond contents of these kimberlites ranges from 10 to 46 cpht. Hypabyssal intrusions are documented at both ca. 600 Ma and early Cambrian (circa 538-520Ma). The early Cambrain bodies typically are defined by being rich in Mg-ilmentite, and with lower contents of lherzolite-derived xenocryst minerals. These intrusions have a poor diamond endowment, or are barren of diamond. Diversity in mantle signature and diamond tenor coupled with episodic kimberlite magmatism with contrasting emplacement styles indicates a fair degree of lithospheric complexity within the northwestern portion of the Archean Slave Craton and eastern portions of the Paleoproterozoic Wopmay Orogeny.

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