A detrital zircon test of large-scale terrane displacement along the Arctic margin of North America

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SUPPLEMENTAL METHODS

Data Compilation

Detrital zircon U-Pb data were compiled from previously published samples of Tonian–Cambrian strata from the North Slope subterrane and northwestern Laurentian autochthon (i.e., Yukon block and Mackenzie platform), as well as newly reported samples of Tonian–Cambrian strata from the Yukon block presented herein (see below; Fig. S1; Tables S1–3).
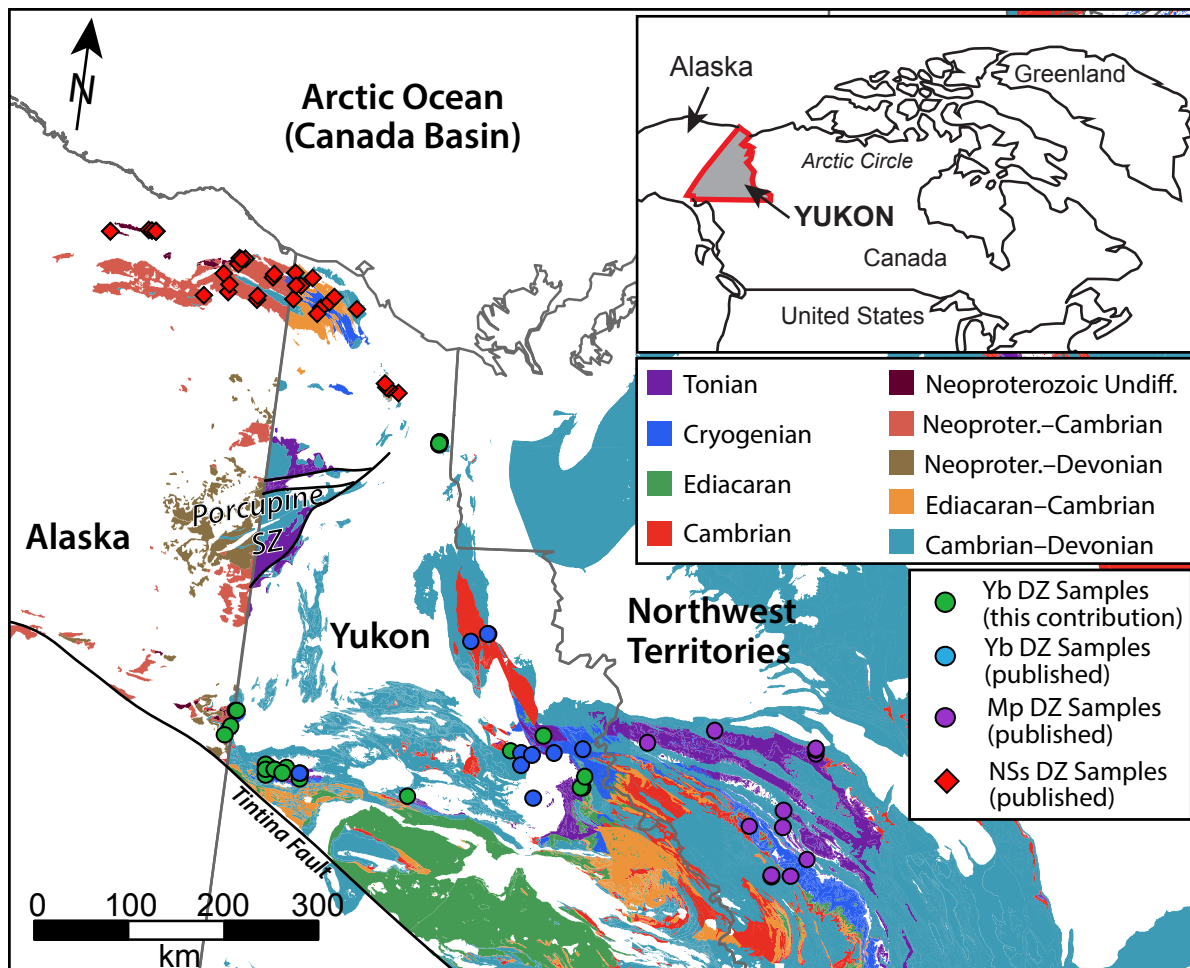
Figure S1. Simplified geological map of Neoproterozoic–Cambrian rocks in northeastern Alaska and northwestern Canada modified after Wilson et al. (2015) and Colpron et al. (2016) showing the locations of published and new samples reported herein (see Table S1). See Figure 1 from the main manuscript for the major terrane or paleogeographic element boundaries and note that only a small number of regionally significant faults are shown here. Yb—Yukon block; MP—Mackenzie platform; NSs—North Slope subterrane; SZ–Shear Zone.

Data Filtering

All analyses in this compilation were filtered to exclude samples that do not overlap with concordia at the 2σ level using error propagation. This was calculated starting from the equation for discordance:

$$disc = 1 - \left(\frac{t_{\frac{206Pb}{238U}}}{t_{\frac{207Pb}{206Pb}}} \right) = 1 - \frac{t_{68}}{t_{76}} = 1 - t_{68}t_{76}^{-1}$$

We incorporate the error propagation equation (assuming no covariance):

$$\sigma_x^2 = \sigma_u^2 \left(\frac{\partial x}{\partial u} \right)^2 + \sigma_v^2 \left(\frac{\partial x}{\partial v} \right)^2 + 2\sigma_{uv}^2 \left(\frac{\partial x}{\partial u} \right) \left(\frac{\partial x}{\partial v} \right)$$

Or:

$$\sigma_{disc}^2 \approx \sigma_{t68}^2 \left(\frac{\partial disc}{\partial t_{68}} \right)^2 + \sigma_{t76}^2 \left(\frac{\partial disc}{\partial t_{76}} \right)^2$$

We then compute the partial derivatives:

$$\left(\frac{\partial disc}{\partial t_{68}} \right)^2 = \left(\frac{-1}{t_{76}} \right)^2$$

$$\left(\frac{\partial disc}{\partial t_{76}} \right)^2 = \left(\frac{t_{68}}{(t_{76})^2} \right)^2$$

To produce the following error propagation equation:

$$\sigma_{disc}^2 \approx \sigma_{t68}^2 \left(\frac{-1}{t_{76}} \right)^2 + \sigma_{t76}^2 \left(\frac{t_{68}}{(t_{76})^2} \right)^2$$

Analyses were then excluded where discordance was >10% and/or reverse discordance was >5% considering 2σ uncertainty as follows:

$$disc - \sigma^2_{disc} > 10\%$$

and

$$disc + \sigma^2_{disc} < -5\%$$

Analyses were also excluded if the 2σ uncertainty for either the $^{206*}Pb/^{238}U$ or $^{207}Pb/^{206}Pb$ date was > 10% of the isotopic date, regardless of which isotope system was employed for the "best age" selection (see details in Table S2 for new data presented herein).

After this filtering, only data from samples where n ≥ 40 were included in this compilation. All data that fit these criteria were then binned by stratigraphic age. The small sample size (n=101) of the resulting Cryogenian age bin from the North Slope subterrane relative to all other age bins is ascribed to the paucity of Cryogenian strata preserved in Arctic Alaska. Therefore, in order to maintain statistically robust sample sizes, we combined the Cryogenian and Tonian age bins. All filtered data were placed into either a Tonian–Cryogenian, Ediacaran, or Cambrian time bin for statistical analysis using commonly applied non-parametric similarity-dissimilarity metrics (see below).

Individual sample data were sorted using cutoffs of 900, 1200, and 1500 Ma for $^{206*}Pb/^{238}U$ versus $^{207}Pb/^{206}Pb$ dates. For grains with a $^{206*}Pb/^{238}U$ date younger than the cutoff, the $^{206*}Pb/^{238}U$ date was accepted as the "best age," and for grains older than the cutoff, the $^{207}Pb/^{206}Pb$ date was utilized. A 1500 Ma cutoff was applied for all the statistical analyses comparing age populations between the North Slope subterrane versus autochthonous northwestern Laurentia, as well as for the probability density plots (PDPs) and their qualitative descriptions presented below (Fig. S2). All three age cutoffs were also applied for self-comparison of the datasets to determine the effects on various statistical tests (see main text).
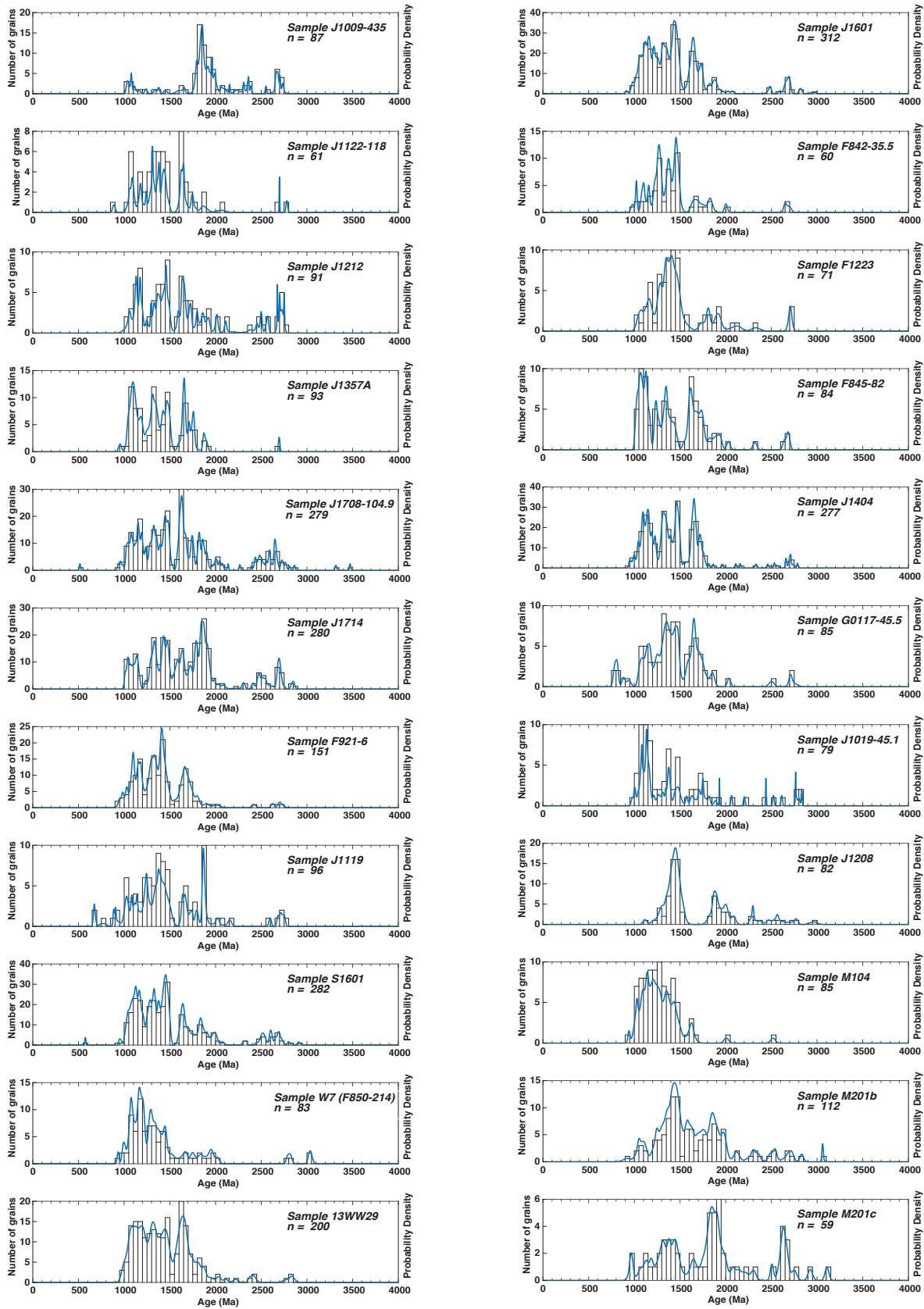
Figure S2. Histograms and probability density plots of individual new samples presented herein.

Statistical Analyses

Detrital zircon geochronology U-Pb data from our compilation (Table S3) were analyzed using DZstats following methods outlined in Saylor and Sundell (2016) to test the null hypothesis that Neoproterozoic–Cambrian sandstone samples from the North Slope subterrane and northwestern Laurentian autochthon were derived from a common source region. Statistical values used to assess whether to accept or reject this null hypothesis (Table 1; Fig. 2) are approximated from Saylor and Sundell (2016). These values are not regarded as strict cutoffs, but rather rough guidelines for assessing the relative probability that two age populations of interest were drawn from the same parent population, assuming random sampling. We used five statistical metrics to evaluate the degree of similarity or dissimilarity between zircon age populations of interest— Cross-Correlation coefficient, Likeness coefficient, and Similarity coefficient were used to compare PDPs (2σ uncertainty), as well as the Kolmogorov-Smirnov (K-S) test D Statistic, and the Kuiper test V Statistic (see Figs. 2–3 in main text).

Analytical Methods

Zircon Separation, Mounting, and Imaging

Zircon was separated from sandstone samples for U-Pb geochronology using standard mineral separation procedures (*i.e.,* crushing, sieving, water density separation, magnetic separation, and heavy liquid density separation) at Dartmouth College, University of Iowa, and Boise State University. Separated zircon grains were mounted together with U-Pb standards in a 1" epoxy ring, polished to expose their interiors, and then imaged using cathodoluminescence (CL) at the University of Iowa using a Gatan Chroma CL2 unit mounted on a Hitachi S3400 scanning electron microscope (SEM) or at Boise State University with a Gatan MiniCL unit mounted to a JEOL JSM-1300 SEM. Spot locations for laser ablation–inductively coupled plasma mass spectrometry (LA–ICPMS) were chosen from the CL images to avoid inherited cores, complex zonation, domain boundaries, and metamict zones.

U-Pb LA–ICPMS Analyses

Detrital zircon U-Pb isotope ratios were analyzed by LA–ICPMS at the University of Arizona Laserchron Center (12 samples), Boise State University Isotope Geology Laboratory (8 samples), or the University of Adelaide (3 samples). These new data are reported in Table S2.

University of Arizona Laserchron Center. Zircon grains from these twelve samples were ablated using a Photon Machines Analyte G2 Excimer laser with a HelEx ablation cell and analyzed using either a ThermoScientific Element2 single collector high resolution (HR)–ICPMS or Nu Instruments multicollector HR–ICPMS. Analytical procedures followed methods outlined in Gehrels et al. (2006, 2008) and Gehrels and Pecha (2014). For analyses using the Element2, which sequences rapidly through U, Th, and Pb isotopes, ion intensities were detected with a secondary electron multiplier (SEM). The SEM operates in pulse-counting mode for signals <50K cps, in both pulse-counting and analog mode for signals between 50K and 4M cps, and in analog mode >4M cps. Calibration between pulse-counting and analog signals was determined line-by-line for signals between 50K and 4M cps and was applied to 4M cps signals. Four intensities were determined and averaged for each isotope, with dwell times of 0.0052 seconds for 202, 0.0075 seconds for 204, 0.0202 seconds for 206, 0.0284 seconds for 207, 0.0026 seconds for 208, 0.0026 seconds for 232, and 0.0104 seconds for 238. Zircons were ablated to a depth of ~12 μm using a spot diameter of ~20 μm at a rate of ~0.8 μm/s, using a laser energy density of ~5 J/cm^2, a repetition rate of 8 Hz, and an ablation time of 10 seconds. Sensitivity with these settings is ~5,000 cps/ppm. Each analysis consists of 5 seconds counting on peaks with the laser off for backgrounds and 10 seconds with the laser firing for peak intensities. This is followed by a 20 second delay to purge the previous sample and save files.

Analyses conducted with the Nu Instruments HR-ICPMS were made in static mode using Faraday collectors with 3x10^{11} ohm resistors for measuring ^{238}U, ^{232}Th, ^{208}Pb-^{206}Pb, and ion counters for ^{204}Pb and ^{202}Hg. Zircons were ablated to a depth of ~12 μm at a rate of ~0.8 μm/s, using a spot diameter of ~30 μm, and ablated material was carried in Helium gas to the plasma source. Ion yields are ~0.8 mv per ppm, and each analysis consisted of a single 15 second integration on peaks with the laser off for backgrounds, then 15 one-second integrations with the laser firing, and a 30 second delay to completely purge the previous sample prior to the next analysis.

All sample analyses were bracketed with the Sri Lanka (^{206}Pb/^{238}U age of 563.2 ± 4.8 Ma, 2σ; Gehrels et al., 2008), R33 (^{206}Pb/^{238}U age of 420.53 ± 0.16 Ma, 2σ; Mattinson, 2010), and FC1 (^{207}Pb/^{206}Pb age of 1099.0 ± 0.6 Ma, 2σ; Paces and Miller, 1993) reference zircons to assess reproducibility. ^{204}Hg interference with ^{204}Pb was taken into account for ^{202}Hg measurement during

laser ablation and ^{204}Hg was subtracted according to the natural ^{202}Hg/^{204}Hg ratio of 4.35. This Hg correction is not significant for most analyses because Hg backgrounds are low at the Laserchron facility (generally ~150 cps at mass 204). Common Pb corrections are calculated using the Hg-corrected ^{204}Pb values and assuming an initial Pb composition (Stacey and Kramers, 1975). Uncertainties for ^{206}Pb/^{204}Pb (1.5%) and ^{207}Pb/^{204}Pb (0.3%) were applied to these compositional values based on variation in the Pb isotopic composition of crystalline rocks. For each analysis, the errors in determining ^{206}Pb/^{238}U and ^{206}Pb/^{204}Pb resulted in a measurement error of ~1-2% (at 2σ level) in the ^{206}Pb/^{238}U age. Errors in ^{207}Pb/^{206}Pb and ^{206}Pb/^{204}Pb measurements also result in ~1-2% (at 2σ level) uncertainty in age for grains that are >1000 Ma but are substantially larger for younger grains due to the low intensity of the ^{207}Pb signal. Uncertainties on the U-Pb isotopic data include only measurement errors. These background-corrected analytical data were reduced from raw ratios to ^{206}Pb/^{238}U, ^{207}Pb/^{235}U, and ^{207}Pb/^{206}Pb ratios, which were used to calculate apparent ages using the AgeCalc macro. Raw data and calculated "best ages" using 900, 1200, and 1500 Ma cutoffs are presented in Table S2.

Boise State University Isotope Geology Laboratory. Zircons were analyzed using a ThermoElectron X-Series II quadrupole ICPMS and New Wave Research UP-213 Nd:YAG UV (213 nm) laser ablation system. In-house analytical protocols, standard materials, and data reduction software were used to acquire and calibrate U–Pb dates, a suite of high field strength elements (HFSEs), and rare earth elements (REEs).

During analyses, zircon grains were ablated with a 25 µm diameter laser spot, using fluence and pulse rates of 5 J/cm^2 and 10 Hz, respectively, for 45 seconds (15 second gas blank, 30 second ablation) that excavated a ~25 µm deep pit. Ablated material was carried via He gas stream at a rate of 1.2 L/minute to the plasma. Dwell times were 5 ms for Si and Zr, 200 ms for ^{49}Ti, then subtracted from the raw count rate for each analyte. Ablation pits that seem to have intersected glass or mineral inclusions were identified based on Ti and P anomalies. U–Pb dates calculated from these analyses are considered valid if the U–Pb ratios do not appear to have been affected by the inclusions. Analyses with mass 204 values above baseline are interpreted to reflect common Pb contamination were rejected. Background-subtracted count rates for elemental concentrations were each normalized to ^{29}Si and calibrated to NIST SRM-610 and NIST SRM--612 standards. Crystallization temperature was calculated from the Ti-in-zircon thermometer (Watson et al.,

2006). Because there are no constraints on the activity of TiO_2, an average value in crustal rocks of 0.8 was used.

Instrumental fractionation from background-subtracted ratios was corrected when calculating U–Pb and $^{207}Pb/^{206}Pb$ dates. These dates were also calibrated with interspersed zircon standards and reference materials analyses. Two analyses of the primary Plešovice zircon standard (Sláma et al., 2008) for every 10 unknown analyses were used to monitor time-dependent instrumental fractionation. Then, a secondary correction to $^{206}Pb/^{238}U$ dates was made from analyses of the Seiland (530 Ma, unpublished data, Boise State University Isotope Geology Laboratory) and 15PS123 standards (173 Ma, unpublished data, Boise State University Isotope Geology Laboratory). These zircon standards were measured once per 10 unknown analyses. Results from standard analyses exhibit a linear age bias of several percent, which is related to the ^{206}Pb count rate, and so the secondary correction helps to mitigate matrix-dependent variations due to contrasting compositions and ablation characteristics between the Plešovice zircon standard and other standards and unknowns.

Radiogenic isotope ratio and date uncertainty propagation for all analyses includes uncertainty contributions from counting statistics and background subtraction. A standard calibration uncertainty is propagated into uncertainties. This standard calibration uncertainty is the local standard deviation of the polynomial fit to the interspersed primary standard measurements versus time for the U/Pb fractionation factor; these uncertainties range from 1.06 to 1.33% (2σ) for $^{206}Pb/^{238}U$ dates. Raw data and calculated "best ages" using 900, 1200, and 1500 Ma cutoffs are presented in Table S2.

University of Adelaide. Zircon grains were analyzed at the University of Adelaide using an Agilent 7500cs ICPMS coupled with a New Wave New Wave (213 nm) Nd-YAG laser with a spot size of 30μm, frequency of 5 Hz, and a laser intensity of 75%. Data acquisition involved 40 seconds background measurement, 10 seconds of beam stabilization, and 30 seconds sample ablation. Isobaric interference of ^{204}Hg means corrections for common Pb where not made; however, mass 204 was monitored and analyses showing above background counts of mass 204 were discarded. Other operating conditions and equipment utilized are outlined by Payne et al. (2006). Zircon standard GJ-1 ($^{206}Pb/^{238}U$ age = 600.7 ± 1.1 Ma and $^{207}Pb/^{235}U$ age = 602.2 ± 1.0 Ma (Jackson et al., 2004)) was used as a primary standard and Plešovice ($^{206}Pb/^{238}U$ age = 337.13 ± 0.37 Ma,

(Sláma et al., 2008)) was used as a secondary standard. U–Pb fractionation was corrected using the GEMOC GJ-1 zircon standard (TIMS normalization data $^{207}Pb/^{206}Pb$ = 608.3 Ma, $^{206}Pb/^{238}U$= 600.7 Ma and $^{207}Pb/^{235}U$= 602.2 Ma, Jackson et al., 2004) and accuracy was checked using an in-house Sri Lankan zircon standard (BJWP-1, ca. 727 Ma). Data were then processed using Iolite (Hellstrom et al., 2008) for isotopic ages and U and Th counts.

SUPPLEMENTAL RESULTS

Sample Descriptions

Cambrian

J1009-435. Sample J1009-435 is from the upper Cambrian–Middle Ordovician Jones Ridge Formation of the Tadonduk inlier along the Yukon-Alaska border (Fig. S1; Tables S1, S2; Young, 1982; Taylor et al., 2015). This sample was collected from an ~30 cm thick quartz arenite bed directly above a prominent ~5 m thick paleokarst horizon, which marks the contact between the lower Cambrian Funnel Creek and upper Cambrian Jones Ridge formations (Taylor et al., 2015). This sample has a prominent 1700–2000 Ma age population with an 1850 Ma peak, a secondary 2650–2750 Ma population, and subordinate 1000–1100 and 2300–2400 Ma age peaks (Fig. S2). It also contains minor abundances of 1100–1700, 2000–2300, and 2400–2700 Ma grains. The youngest concordant zircons that pass our filters are 1032 ± 19, 1044 ± 28, and 1047 ± 36 Ma (2σ).

J1122-118. Sample J1122-118 is from the middle-upper Cambrian Slats Creek Formation or informal map unit Csc in the Hart River inlier of north-central Yukon (Fig. S1; Tables S1, S2; Abbott, 1997). This sample of coarse-grained quartz wacke was collected from an irregular ~2-m-deep quartz-sand filled paleokarst horizon developed on the underlying Tonian Callison Lake Formation (Strauss et al., 2015). Prominent U-Pb age populations from this sample range from 1050–1500 and 1600–1900 Ma, with discrete peaks at 1300, 1375, 1450, and 1650 Ma (Fig. S2). Additionally, there are single grains at ca. 2060, 2700, and 2780 Ma. The youngest concordant zircons that pass our filters are 887 ± 27, 1041 ± 46, and 1060 ± 18 Ma (2σ).

J1212. Sample J1212 is from the lower Cambrian Illtyd Formation in the Illtyd Range of northeastern Yukon (Fig. S1; Tables S1, S2; Fritz, 1991). This sample of medium-grained hematite-cemented quartz wacke was collected ~76 m above the basal contact with the

Paleoproterozoic Quartet Group in the type section of the Illtyd Formation (Fritz, 1991, 1997). Prominent U-Pb age populations from this sample range from 1000–1200, 1300–1500, 1600–1700, and 2650–2750 Ma, with scattered populations of 1700–2100 and 2500–2600 Ma grains (Fig. S2). The youngest concordant zircons that pass our filters are 1014 ± 68, 1046 ± 43, and 1061 ± 27 Ma (2σ).

J1357A. Sample J1357A is from the lower Cambrian Illtyd(?) Formation or informal map unit C1 in the White Uplift of northern Yukon (Fig. S1; Tables S1, S2; Norris, 1981, 1997; Morrow, 1989; Dyke, 1997; Fritz, 1997). This sample was collected from medium-grained quartz arenite with abundant *Skolithos* burrows, ~0.5 m above an angular unconformity with unnamed Ediacaran siliciclastic rocks of informal map unit Pu (Dyke, 1997; Strauss, *unpublished data*). Prominent U-Pb age populations from this sample range from 1050–1200, 1250–1400, 1450–1500, and 1600–1700 Ma, with a subordinate 1750–1800 Ma peak and small 1900–2000 Ma peak (Fig. S2). The youngest concordant zircons that pass our filters are 954 ± 29, 1041 ± 22, and 1050 ± 53 Ma (2σ).

J1708-104.9. Sample J1708-104.9 is from the lower-middle Cambrian Shell Creek Formation (previously map unit PH5, Mustard and Roots, 1997) in the Coal Creek inlier of west-central Yukon (Fig. S1; Tables S1, S2; Busch et al., *accepted*). This sample was collected from a <30 cm thick trough cross-bedded medium- to coarse-grained sublitharenite horizon interbedded with polymict cobble conglomerate just above the sub-Shell Creek unconformity (Busch et al., *accepted*). The most prominent U-Pb age peak in this sample is between 1550 and 1700 Ma, and other major age populations include 1000–1200, 1250–1350, 1400–1500, 1700–1750, and 1800–1950 Ma (Fig. S2). There are also smaller 1950–2150 and 2350–2900 Ma age populations and individual ca. 3300 and 3470 Ma grains. The youngest concordant zircons that pass our filters are 516 ± 13, 934 ± 14, and 957 ± 18 Ma (2σ).

J1714. Sample J1714 is from the lower-middle Cambrian Shell Creek Formation (previously map unit PH5, Mustard et al., 1988) in the Coal Creek inlier of west-central Yukon (Fig. S1; Tables S1, S2; Busch et al., *accepted*). This sample was collected ~7 m above an erosional contact with the early Ediacaran Mount Ina Formation and consists of amalgamated fine-grained lithic arenite to sublitharenite with planar lamination. This sample contains prominent U-Pb age populations that

range from 1000–1200, 1250–1350, 1400–1500, 1550–1650, 1700–1950, and 2650–2750 Ma (Fig. S2). There are additional smaller populations between 1950 and 2900 Ma, and the youngest concordant zircons that pass our filters are 1009 ± 27, 1011 ± 14, and 1013 ± 23 Ma (2σ).

Ediacaran

F921-6. Sample F921-6 is from the Ediacaran Last Chance Formation (previously map unit PH4, Mustard and Roots, 1997) in the Coal Creek inlier of west-central Yukon (Fig. S1; Tables S1, S2; Busch et al., *accepted*). This sample was collected from amalgamated, hummocky cross-stratified very fine-grained calcareous quartz arenite approximately 6 m above the top of the informal Gladman member (Busch et al., *accepted*). Prominent U-Pb age populations from this sample range from 1020–1100, 1150–1200, 1250–1350, 1350–1500, and 1600–1850 Ma (Fig. S2). There are also individual zircon grains scattered between 1900 and 2725 Ma, and the youngest concordant zircons that pass our filters are 948 ± 24, 949 ± 61, and 979 ± 29 Ma (2σ).

J1119. Sample J1119 is from the Ediacaran upper Tindir Group in the Tatonduk inlier of the Yukon-Alaska border region (Fig. S1; Tables S1, S2; Young, 1982; Macdonald et al., 2018). This sample was collected along the Tatonduk River from a very coarse-grained and normal graded sublitharenite horizon interbedded with grey-black shale. This sample contains a broad U-Pb age population from 1000–1550 Ma with peaks at ca. 1250, 1350–1400, and 1850–1950 Ma (Fig. S2). There are additional small zircon populations between 670–930 and 2000–2750 Ma, and the youngest concordant zircons that pass our filters are 672 ± 15, 677 ± 26, and 766 ± 74 Ma (2σ).

S1601. Sample S1601 is from an Ediacaran portion of undifferentiated map unit Pu in the White Uplift of northern Yukon (Fig. S1; Tables S1, S2; Norris, 1981, 1997; Morrow, 1989; Dyke, 1997; Strauss, *unpublished data*). This sample was collected from a >4 m thick horizon of trough cross-stratified and silica-cemented quartz arenite directly beneath the lower Cambrian Illtyd(?) Formation (Fritz, 1997) or informal map unit C1 (Morrow, 1989). Prominent U-Pb age populations occur between 1000–1200 and 1250–1500 Ma with smaller age peaks between 1600–1750 and 1800–2000 Ma (Fig. S2). There is also a moderately small U-Pb age population between 2450 and 2900 Ma. The youngest concordant zircons that pass our filters are 575 ± 12, 948 ± 18, and 967 ± 22 Ma (2σ).

W7 (F850-214). Sample W7 is from the Ediacaran Gametrail Formation in the Wernecke inlier of eastern Yukon (Fig. S1; Tables S1, S2; Macdonald et al., 2018). The sample was collected from the base of a well-sorted, medium-grained quartz arenite horizon with minor, shard-like lithic fragments. Prominent U-Pb age populations from this sample range from 1050–1300 and 1300–1500 Ma, with scattered 930–1050 and 1500–2020 Ma populations and a small proportion of grains between 2790 and 3045 Ma (Fig. S2). The youngest concordant zircons that pass our filters are 934 ± 22, 988 ± 28, and 993 ± 25 Ma (2σ).

Cryogenian

13WW29. Sample 13WW29 is from a Cryogenian portion of undifferentiated map unit Pu in the White Uplift of northern Yukon (Fig. S1; Tables S1, S2; Norris, 1981, 1997; Morrow, 1989; Dyke, 1997; Strauss, *unpublished data*). This sample was collected from an ~6 m thick outcrop of poorly exposed hematite-cemented quartz wacke that sits ~ 3 m above mafic volcanic and volcaniclastic rocks of an unnamed volcanic unit. This sample has a broad U-Pb age population between 1000 and 1500 Ma, a prominent 1550–1750 Ma population, and a minor 1800–1900 Ma population (Fig. S2). Additionally, there are scattered ca. 1950–2850 Ma grains. The youngest concordant zircons that pass our filters are 988 ± 49, 990 ± 42, and 991 ± 49 Ma (2σ).

J1601. Sample J1601 is from a Cryogenian portion of undifferentiated map unit Pu in the White Uplift of northern Yukon (Fig. S1; Tables S1, S2; Norris, 1981, 1997; Morrow, 1989; Dyke, 1997; Strauss, *unpublished data*). This sample was collected from the same ~6 m thick outcrop of poorly exposed hematite-cemented quartz wacke that was sampled in 13WW29 above. This sample has prominent U-Pb age populations that range from 1000–1250, 1250–1500, and 1550–1750 Ma, and subordinate populations from 1800–2070 and 2450–2950 Ma (Fig. S2). The youngest concordant zircons that pass our filters are 914 ± 28, 972 ± 30, and 978 ± 32 Ma (2σ).

F842-35.5. Sample F842-35.5 is from the Cryogenian Eagle Creek Formation of the Coal Creek inlier in west-central Yukon (Fig. S1; Tables S1, S2; Macdonald et al., 2018). This sample was collected from fine- to medium-grained silty quartz wacke with rare cobble-sized clasts of dolostone, quartzite, and mafic volcanic rocks. Prominent U-Pb age populations in this sample

range from 1200–1300 and 1350–1500 Ma (Fig. S2); smaller ca. 980–1160 and 1600–1850 Ma populations also exist. There is a single ca. 2000 Ma grain and two grains between 2650–2700 Ma. The youngest concordant zircons that pass our filters are 980 ± 34, 1021 ± 22, and 1023 ± 13 Ma (2σ).

F1223. Sample F1223 is from the Cryogenian Twitya Formation in the Wernecke inlier of eastern Yukon (Fig. S1; Tables S1, S2; Macdonald et al., 2018). This sample was collected from a thin-bedded sandy green siltstone horizon within thick-bedded polymict conglomerate of the basal Twitya Formation that rests disconformably on the Tonian Hematite Creek Group (Eisbacher, 1981; Macdonald et al., 2018). Prominent U-Pb age populations from this sample range from 1000–1200 and 1250–1500 Ma, and smaller populations occur between 1700–1950 Ma and ca. 2700 Ma (Fig. S2). There are also scattered populations of ca. 1550 and 2050–2150 Ma grains. The youngest concordant zircons that pass our filters are 1034 ± 49, 1049 ± 35, and 1076 ± 30 Ma (2σ).

Tonian

F845-82. Sample F845-82 is from the informal "upper shale" unit of the upper Fifteenmile Group in the Tatonduk inlier along the Alaska-Yukon border (Fig. S1; Tables S1, S2; Macdonald et al., 2011; Macdonald and Cohen, 2011). This sample consists of coarse-grained quartz arenite collected from a m-scale channel within black and gray shale that is interbedded with lime mudstone and calcisiltite from just northwest of Mount Slipper. This sample contains prominent U-Pb age populations that range from 1000–1170, 1230–1450, and 1600–1800 Ma, with scattered populations between 1800–2030 and 2640–2690 Ma (Fig. S2). The youngest concordant zircons that pass our filters are 1016 ± 24, 1018 ± 25, and 1032 ± 23 Ma (2σ).

J1404. Sample J1404 is from the Tonian upper Fifteenmile Group of the Tatonduk inlier along the Alaska-Yukon border region (Fig. S1; Tables S1, S2; Macdonald et al., 2011; Macdonald and Cohen, 2011). This sample was collected from the same horizon as F845-82. Prominent U-Pb age populations from this sample range from 1000–1250, 1300–1500, and 1600–1800 Ma, with scattered populations between 2000 and 2785 Ma (Fig. S2). The youngest concordant zircons that pass our filters are 945 ± 18, 957 ± 24, and 964 ± 22 Ma (2σ).

G0117-45.5. Sample G0117-45.5 is from the upper Fifteenmile Group of the Tatonduk inlier along the Alaska-Yukon border (Fig. S1; Tables S1, S2; Macdonald et al., 2011; Macdonald and Cohen, 2011). The sample was collected from a light green tuffaceous lithic wacke within the "upper carbonate" unit on the west side of Mount Slipper, approximately 15 m above a black shale horizon that is dated to 810.7 ± 6.3 Ma (Cohen et al., 2017). This horizon is approximately correlative with the 811.51 ± 0.25 Ma tuff interbedded within Reefal assemblage carbonates in the upper Fifteenmile Group from the Coal Creek inlier (Macdonald et al., 2010). There are prominent U-Pb peaks in this sample that span 1050–1200, 1250–1500, and 1580–1860 Ma (Fig. S2). Additionally, there are subordinate peaks at 785 and 940 Ma and scattered populations between 2000 and 2750 Ma. The youngest concordant zircons that pass our filters are 785 ± 35, 793 ± 38, and 802 ± 42 Ma (2σ), which are all within uncertainty of previous geochronological data for this unit (Macdonald et al., 2010; Cohen et al., 2017). This sample was originally processed as a tuff, and faceted zircon grains were preferentially picked for analysis. As a result, the ca. 800 Ma peak (n=4) is disproportionately large and does not represent the true distribution of this age population in the sample. However, these four grains do not affect our statistical results.

J1019-45.1. Sample J1019-45.1 is from the Tonian Callison Lake Formation in the Coal Creek inlier of Yukon (Fig. S1; Tables S1, S2; Strauss et al., 2015). This sample was collected from a poorly sorted quartz wacke horizon that rests disconformably on the underlying Craggy Dolostone of the Fifteenmile Group (Strauss et al., 2015). This sample contains a prominent 1000–1200 Ma U-Pb age population, and subordinate peaks that range from 1300–1400 and 1700–1800 Ma (Fig. S2). There are also smaller populations between 1200–1300, 1400–1700, and 1800–2930 Ma. The youngest concordant zircons that pass our filters are 977 ± 24, 1003 ± 22, and 1007 ± 18 Ma (2σ).

J1208. Sample J1208 is from the Tonian Chandindu Formation (Fifteenmile Group) of the Coal Creek inlier of Yukon (Fig. S1; Tables S1, S2; Macdonald et al., 2012; Kunzmann et al., 2014). This sample consists of fine- to medium-grained lithic arenite and comes from just below the first major patch reef of the Reefal assemblage. This sample is dominated by a prominent 1200–1550 U-Pb age population and subordinate 1800–2100 Ma population (Fig. S2). There are small

populations spread evenly between 2270–2960 Ma. The youngest concordant zircons that pass our filters are 1116 ± 42, 1212 ± 57, and 1275 ± 67 Ma (2σ).

M104. Sample M104 is from the Tonian Tarn Lake Formation, just west of Mount Profeit in the Wernecke inlier of Yukon (Fig. S1; Tables S1, S2; Turner et al., 2011). This sample was collected from an outcrop of fine-grained gray-green quartz arenite. The sample is characterized by a single, broad U-Pb age population between 1000 and 1500 Ma, as well as a minor 1590–1650 Ma zircons (Fig. S2). There are also individual ca. 940, 2000, and 2500 Ma grains. The youngest concordant zircons that pass our filters are 941 ± 22, 1012 ± 39, and 1014 ± 48 Ma (2σ).

M201b. Sample M201b is from the Tonian Reefal assemblage (upper Fifteenmile Group) in the Coal Creek inlier of Yukon (Fig. S1; Tables S1, S2; Macdonald et al., 2012). This sample was collected from an outcrop of finely laminated sandy mudstone interbedded with silicified stromatolitic dolostone. There are is a broad U-Pb age population in this sample that ranges from 1000–2000 Ma, with prominent peaks between 1400–1500 and 1800–1900 Ma and a smaller peak at ca. 1050 Ma (Fig. S2). There are also scattered U-Pb age populations between 2100 and 3060 Ma. The youngest concordant zircons that pass our filters are 924 ± 84, 1024 ± 50, and 1049 ± 27 Ma (2σ).

M201c. Sample M201c is from the Tonian Reefal assemblage (upper Fifteenmile Group) in the Coal Creek inlier of Yukon (Fig. S1; Tables S1, S2; Macdonald et al., 2012). This sample was collected 1 meter above sample M201b and consists of finely laminated brown sandy siltstone interbedded with silicified stromatolitic dolostone. Prominent U-Pb age populations from this sample range from 1050–1520, 1660–2300, and 2600–2700 Ma, with a smaller population of 950–1000 Ma and scattered 2750–3100 Ma grains (Fig. S2). The youngest concordant zircons that pass our filters are 963 ± 50, 968 ± 32, and 1068 ± 61 Ma (2σ).

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SUPPLEMENTAL DATA TABLES

TABLE S1: SUMMARY OF NEW AND COMPILED DETRITAL ZIRCON GEOCHRONOLOGY SAMPLES USED IN THIS STUDY

Sample	IGSN	Map unit	Latitude°	Longitude°	Age	Location	Tectonic Element	n	Source
J1009-435	IEJVS0001	Jones Ridge Fm	65.1105500	-141.0174167	Cambrian	Tatonduk inlier	Yb	87	This Study
J1122-118	IEJVS0002	Slats Creek Fm	64.6194444	-136.9266389	Cambrian	Hart River inlier	Yb	61	This Study
J1212	IEJVS0003	Illtyd Fm	65.1021944	-134.6882500	Cambrian	Illtyd Range	Yb	91	This Study
J1357A	IEJVS0004	Illtyd Fm	67.9706389	-136.7648056	Cambrian	White Uplift	Yb	93	This Study
J1708-104.9	IEJVS0005	Shell Creek Fm	64.7914200	-140.1444780	Cambrian	Coal Creek inlier	Yb	279	This Study
J1714	IEJVS0006	Shell Creek Fm	64.7434760	-140.1287480	Cambrian	Coal Creek inlier	Yb	280	This Study
F921-6	IEJVS0007	Last Chance Fm	64.7810333	-140.0642333	Ediacaran	Coal Creek inlier	Yb	151	This Study
J1119	IEJVS0008	Tindir Gp	65.0223611	-141.1395833	Ediacaran	Tatonduk inlier	Yb	96	This Study
S1601	IEJVS0009	Map Unit Pu	67.9800000	-136.7600000	Ediacaran	White Uplift	Yb	282	This Study
W7 (F850-214)	IEJVS000A	Gametrail Fm	64.8731667	-133.0078833	Ediacaran	Wernecke inlier	Yb	83	This Study
13WW29	IEJVS000B	Map Unit Pu	67.9927770	-136.7557220	Cryogenian	White Uplift	Yb	200	This Study
J1601	IEJVS000C	Map Unit Pu	67.9927770	-136.7557220	Cryogenian	White Uplift	Yb	312	This Study
F842-35.5	IEJVS000D	Eagle Creek Fm	64.6929167	-140.1130167	Cryogenian	Coal Creek inlier	Yb	60	This Study
F1223	IEJVS000E	Twitya Fm	64.7666667	-133.0500000	Cryogenian	Wernecke inlier	Yb	71	This Study
F845-82	IEJVS000F	Fifteenmile Gp	65.2638667	-140.9710833	Tonian	Tatonduk inlier	Yb	84	This Study
J1404	IEJVS000H	Fifteenmile Gp	65.2654833	-140.9429667	Tonian	Tatonduk inlier	Yb	277	This Study
G0117-45.5	IEJVS000G	Fifteenmile Gp	65.2544330	-133.9535830	Tonian	Tatonduk inlier	Yb	85	This Study
J1019-45.1	IEJVS000I	Callison Lake Fm	64.6886000	-139.3528167	Tonian	Coal Creek inlier	Yb	79	This Study
J1208	IEJVS000J	Chandindu Fm	64.7839167	-139.6691667	Tonian	Coal Creek inlier	Yb	82	This Study
M104	IEJVS000K	Tarn Lake Fm	64.7714167	-133.1081667	Tonian	Wernecke inlier	Yb	85	This Study
M201b	IEJVS000L	Fifteenmile Gp	64.7540556	-139.9387222	Tonian	Coal Creek inlier	Yb	112	This Study
M201c	IEJVS000M	Fifteenmile Gp	64.7540556	-139.9387222	Tonian	Coal Creek inlier	Yb	59	This Study
07CL-1442A	-	Abraham Plains Fm	-	-	Tonian	Mackenzie Mtns	Mp	41	Leslie, 2009
RAS06-188A	-	Little Dal Gp	-	-	Tonian	Mackenzie Mtns	Mp	63	Leslie, 2009
07CL-1553A	-	Backbone Ranges Fm	-	-	Cambrian	Mackenzie Mtns	Mp	63	Leslie, 2009
CL06-44A	-	Sekwi Fm	-	-	Cambrian	Mackenzie Mtns	Mp	68	Leslie, 2009
EM06-113B	-	Franklin Mountain Fm	-	-	Cambrian	Mackenzie Mtns	Mp	49	Leslie, 2009
CL06-47A	-	Backbone Ranges Fm	-	-	Ediacaran	Mackenzie Mtns	Mp	52	Leslie, 2009
CL06-48A	-	Keele Fm	-	-	Cryogenian	Mackenzie Mtns	Mp	57	Leslie, 2009
07-LG-14-A (B)	-	Saline River Fm	-	-	Cambrian	Mackenzie Mtns	Mp	95	Hadlari et al., 2012
07-YHL-44-A (A)	-	Saline River Fm	-	-	Cambrian	Mackenzie Mtns	Mp	108	Hadlari et al., 2012
88PF-5	-	Illtyd Fm	-	-	Cambrian	Mackenzie Mtns	Mp	88	Lane and Gehrels, 2014
HHP72-72	-	Slats Creek Fm	-	-	Cambrian	Mackenzie Mtns	Mp	91	Lane and Gehrels, 2014
1103NC-1	-	Keele Fm	-	-	Cryogenian	Mackenzie Mtns	Mp	97	Lane and Gehrels, 2014
1105NC-4	-	Rapitan Gp	-	-	Cryogenian	Mackenzie Mtns	Mp	91	Lane and Gehrels, 2014
11-MWB-128	-	Tsezotene Fm	-	-	Tonian	Mackenzie Mtns	Mp	59	Rainbird et al., 2017
11-MWB-129	-	Grafe River Fm	-	-	Tonian	Mackenzie Mtns	Mp	98	Rainbird et al., 2017
11-MWB-130	-	Shattered Range Fm	-	-	Tonian	Mackenzie Mtns	Mp	90	Rainbird et al., 2017
11-MWB-131	-	Abraham Plains Fm	-	-	Tonian	Mackenzie Mtns	Mp	107	Rainbird et al., 2017
95-14	-	Mount Weller Gp	-	-	Tonian	Sadlerochit Mtns	NSs	112	Macdonald et al., 2009; Strauss et al., 2019a
95-15	-	Mount Weller Gp	-	-	Tonian	Sadlerochit Mtns	NSs	96	Macdonald et al., 2009; Strauss et al., 2019a
F608	-	Hula Hula diamictite	-	-	Cryogenian	Sadlerochit Mtns	NSs	101	Macdonald et al., 2009; Strauss et al., 2019a
F1143	-	Mount Weller Gp	-	-	Tonian	Sadlerochit Mtns	NSs	82	Strauss et al., 2013; Strauss et al., 2019a
F1145	-	Mount Weller Gp	-	-	Tonian	Sadlerochit Mtns	NSs	77	Strauss et al., 2013; Strauss et al., 2019a
F1147	-	Redwacke Creek Fm	-	-	Ediacaran	British Mtns	NSs	86	Strauss et al., 2013; Strauss et al., 2019a
F1150	-	Neruokpuk Fm	-	-	Cambrian	British Mtns	NSs	94	Strauss et al., 2013; Strauss et al., 2019a
J1111	-	Malcolm River Fm	-	-	Cambrian	British Mtns	NSs	92	Strauss et al., 2013; Strauss et al., 2019a
J1115	-	Fish Creek Fm	-	-	Ediacaran	British Mtns	NSs	81	Strauss et al., 2013
13-007	-	Neruokpuk Fm	-	-	Cambrian	Barn Mtns	NSs	80	McClelland et al., 2015
13-016	-	Neruokpuk Fm	-	-	Cambrian	Barn Mtns	NSs	84	McClelland et al., 2015
13-018	-	Neruokpuk Fm	-	-	Cambrian	Barn Mtns	NSs	84	McClelland et al., 2015
87LHA27-5	-	Neruokpuk Fm	-	-	Cambrian	British Mtns	NSs	81	Lane et al., 2015; 2016
94LHA10-7A	-	Neruokpuk Fm	-	-	Cambrian	British Mtns	NSs	98	Lane et al., 2015; 2016
94LHA14-3	-	Neruokpuk Fm	-	-	Cambrian	British Mtns	NSs	99	Lane et al., 2015; 2016
12JT31	-	Firth River Gp	-	-	Ediacaran	British Mtns	NSs	75	Johnson et al., 2016
05LF13	-	Neruokpuk Fm	-	-	Cambrian	British Mtns	NSs	82	Johnson et al., 2016
11LF13	-	Neruokpuk Fm	-	-	Cambrian	British Mtns	NSs	85	Johnson et al., 2016
12JT10	-	Neruokpuk Fm	-	-	Cambrian	British Mtns	NSs	83	Johnson et al., 2016
12JT11	-	Neruokpuk Fm	-	-	Cambrian	British Mtns	NSs	81	Johnson et al., 2016
12JT32	-	Neruokpuk Fm	-	-	Cambrian	British Mtns	NSs	51	Johnson et al., 2016
J1107	-	Mount Weller Gp	-	-	Tonian	Shublik Mtns	NSs	84	Strauss et al., 2019a
J1334	-	Fish Creek Fm	-	-	Ediacaran	British Mtns	NSs	91	Strauss et al., 2019a
08ACH018	-	Neruokpuk Fm	-	-	Cambrian	British Mtns	NSs	96	Strauss et al., 2019a
J1327	-	Neruokpuk Fm	-	-	Cambrian	British Mtns	NSs	88	Strauss et al., 2019a
J1349	-	Neruokpuk Fm	-	-	Cambrian	British Mtns	NSs	91	Strauss et al., 2019a
J1470	-	Neruokpuk Fm	-	-	Cambrian	British Mtns	NSs	255	Strauss et al., 2019a
13-083	-	Firth River Gp	-	-	Ediacaran	British Mtns	NSs	261	Colpron et al., 2019
13-116	-	Firth River Gp	-	-	Ediacaran	British Mtns	NSs	268	Colpron et al., 2019
13-131	-	Barn Gp	-	-	Cambrian	Barn Mtns	NSs	265	Colpron et al., 2019
13-139	-	Leffingwell Fm	-	-	Cambrian	British Mtns	NSs	295	Colpron et al., 2019

IGSN—International Geo Sample Number; n—sample size; Fm—Formation; Gp—Group; Mtns—Mountains; Yb—Yukon block; Mp—Mackenzie platform; NSs—North Slope subterrane.

Table S2. New detrital zircon U-Pb geochronological data published in this study. *See accompanying .xlsx file.*

Table S3. Complete detrital zircon U-Pb age dataset used for statistical analyses from this study. *See accompanying .xlsx file.*