Detrital chromites reveal Slave craton's missing komatiite

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FIELD OBSERVATIONS

The Bell and Dwyer Lakes are located ca. 43 km and ca. 25 km north of Yellowknife, respectively (Fig. DR1A). The dominating lithofacies at the sample sites are fuchsite-bearing quartzite and banded iron formation (BIF) that are metamorphosed to lower amphibolite grade. The main foliation strikes N-S with a subvertical dip. Bedding planes are generally subparallel to the main foliation. The quartzite is a white-to-green metamorphosed and recrystallized quartz arenite (>90% quartz; see also Mueller and Pickett, 2005 and Mueller et al., 2005). At both locations, the contact between the quartzite and the underlying basement gneiss (CSBC) is represented by an unconformity (Fig. DR1B). Facing direction is towards the east (Bleeker et al., 1999a; Mueller et al., 2005). The true stratigraphic thickness of the quartzite beds is approximately 20 m at Dwyer Lake and 15 m at Bell Lake locations. Tabular beds of fuchsitic quartzite, ranging from ca. 10 to 50 cm in thickness, occur in association with detrital chromite laminae. These beds are massive-to-planar bedded (Fig. DR1B-C), but locally, cross-stratification has been found preserved as a subordinate bedding type by Mueller and Pickett (2005). Sampling sites for this study were in fuchsitic quartzite horizons where multiple and dense chromite laminae were preserved as shown in Fig. DR1D.

CHROMITE SEPARATION

All seven chromite-bearing quartzite samples were collected with the purpose of separating the heavy mineral fraction concentrated in multiple thin (<2 mm) black laminae. Before physical separation, the mineral content of the laminae was studied using transmitted and reflected light microscope as well as backscatter electron images on a JEOL Microprobe 8900 at the University of Alberta. The heavy mineral laminae comprised relatively pure chromite, with rutile and zircon as accessory phases. Other heavy minerals such as pyrite, magnetite and ilmenite were not observed in these samples. From the seven samples, four samples (three from Bell Lake, RHNWT-14A-2a, RHNWT-14A-2b, RHNWT-14A-3, and one from Dwyer Lake, RHNWT-3A-2) having the highest density of chromite laminae were selected for further crushing and heavy mineral separation. Multiple thin slabs (ca. 3-5 mm) were cut from each hand specimens and these were broken into smaller pieces. Approximately 0.3-0.5 kg of slabs were cut depending on chromite laminae density. Subsequently, the pieces were carefully crushed using an agate mortar. The rock material was sieved on a 50 mesh (297 μ m) disposable nylon seive, then treated either on a Wilfley water table or wash panned until a relatively pure head fraction of chromite was achieved. To ensure that no ferromagnetic minerals (magnetite, pyrrhotite) contaminated the separates, a strong hand magnet was applied to the individual fractions while submersed in ethanol. To separate the paramagnetic chromite grains from the non-magnetic rutile and zircon grains multiple passes of the head fractions were done on a Frantz magnetic barrier separator (current up to 0.4 A). The

majority of the chromite grains in the separates were then carefully dry picked or submersed in ethanol and sucked up by a micro pipette. The final weight of the chromite grain concentrate of the four samples were 0.22-0.45 g. In addition to the chromite concentrates, two whole rock fuchsitic quartzite samples (RHNWT-3A and RHNWT-14A) were crushed to powder on an agate mortar for further chemistry and isotope work (see below).

ANALYTICAL TECHNIQUES

Major oxide chemistry

Four thin sections and one epoxy puck with handpicked chromite grains were polished and carbon-coated for electron microprobe and scanning electron microscope analysis. Backscatter electron images, energy dispersive spectrometry and wavelength dispersive spectrometry were obtained with a JEOL Microprobe 8900 at the University of Alberta. The beam current was set to ~20 nA and the probe beam size was set to 1 μm . Measurements on two different chromite standards (EPS1 NC-chromite and 639-chromite) were done for each 40 measurements of the unknown chromites. Except for within grain transects (Fig. DR2), spots were set either on the center or on the edge of grains (Table DR1). The proportion of ferric iron is calculated by stoichiometric calculations following the procedure by Droop (1987).

Time-series spectra

Time series spectra of platinum-group elements (PGEs) were obtained by laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS) in the Arctic Resources Laboratory (ARL) at the University of Alberta. Representative diagrams are shown in Fig. DR3. We used a Resolution 193 nm excimer laser (Applied Spectra, USA) system connected, via nylon tubing, to a sector-field ICPMS Thermo Element XR (Thermo Fisher Scientific Inc., Bremen, Germany). The mass spectrometer was operated in low mass resolution mode ($M/\Delta M = \text{ca. } 300$). A total of 21 chromite grains were ablated using a spot-size of 130 μm , at a repetition rate of 10 Hz with the laser energy at the target (fluence) regulated at $\sim 5 \text{ J/cm}^2$. Ablation typically lasted for ~ 60 seconds following a 60 second background measurement. The ICP-MS was operated at 1300W and a torch depth of 3.5 mm. Argon (0.8~0.95L/min), helium ($\sim 350 \text{ ml/min}$) and nitrogen gas flow (1~2.5ml/min), torch position and focusing potentials were optimized in order to achieve optimal signals on PGEs and low oxide production rates ($\text{ThO/Th} < 0.1\%$). Data were acquired for ^{27}Al , ^{34}S , ^{49}Ti , ^{51}V , ^{53}Cr , ^{57}Fe , ^{59}Co , ^{60}Ni , ^{62}Ni , ^{63}Cu , ^{66}Zn , ^{71}Ga , ^{99}Ru , ^{101}Ru , ^{103}Rh , ^{105}Pd , ^{126}Te , ^{189}Os , ^{193}Ir , ^{195}Pt , ^{197}Au . ^{57}Fe was used as an internal standard to determine concentrations of Ru, Rh, Pd, Os, Ir and Pt by external calibration against two standards: GSE-1G (USGS Glass Reference Material), and Hoba Iron Meteorite (Hirata and Nesbitt, 1997; Campbell and Humayun, 1999). All data were reduced offline using Iolite v3 (Paton et al.; <https://iolite-software.com/>). Due to the very low concentration of PGEs in chromites (i.e., marginally above or below detection limit), the analytical data of the individual grains are presented as time resolved depth profiles generated during laser ablation processes.

Re-Os isotopes and PGE chemistry

Samples were prepared in three different ways for Re-Os and platinum-group elements (PGE) chemistry. Two bulk rock analyses were performed using approximately 2 g of whole rock powder from quartzite rich in chromite laminae. Unleached chromite samples used approximately 0.1 – 0.4 g of chromite separate. Leached chromite samples used approximately 0.1 g of chromite separate, which was refluxed in 6 N HCl for 24 hours at 100 °C in an attempt to remove metamorphically introduced Re-bearing phases that could potentially affect T_{RD} ages (see below). The samples were left to cool and for any particulates to settle from suspension, then as much HCl as possible was pipetted off from the samples without disturbing the powder residue. 10 ml of 18.2 MΩ Milli-Q water was added to each sample, which were left to settle before pipetting the water off. This step was repeated to ensure dilution and removal of any PGEs contributed from phases soluble in HCl. The samples were subsequently spiked and digested in a high pressure asher, and the remainder of the procedure was identical to unleached samples.

The PGEs and Re were analyzed using isotope dilution techniques modified from Pearson and Woodland (2000). Whole rock powders or chromite separates were precisely weighed with an appropriate amount of a spike, isotopically enriched in ^{99}Ru , ^{106}Pd , ^{185}Re , ^{190}Os , ^{191}Ir , and ^{194}Pt . The sample and spike were added to 30 ml quartz glass vials with inverse *aqua regia* composed of ~2 ml concentrate HCl and ~5 ml concentrate HNO_3 . The vials were closed with a semi-permeable Teflon seal and heated to 290 °C at a confining pressure of ~130 bar for 16 hours in a high pressure asher (HPA), to digest PGE bearing phases and equilibrate the spikes and samples.

Osmium was separated using CHCl_3 solvent extraction, back extracted into HBr (Cohen and Waters, 1996), and purified by micro-distillation (Birck et al., 1997). Following Os extraction, the inverse *aqua regia* was dried before converting Re and the other PGEs to chloride form by drying repeatedly in HCl. Matrix separation was achieved using anion exchange chromatography modified from Pearson and Woodland (2000). Osmium isotopes and abundances were measured using negative thermal ionization mass spectrometry (N-TIMS) on a Thermo Fisher Triton Plus at the Arctic Resources Geochemistry Laboratory (ARGL), University of Alberta, using 10^{12} Faraday Cups (Liu and Pearson, 2014). Mass fractionation was corrected to $^{192}\text{Os}/^{188}\text{Os} = 3.082614$. Accuracy and precision of the Os isotope analyses was assessed through repeated measurements of the DrOsS standard, which yields a long term average $^{187}\text{Os}/^{188}\text{Os} = 0.16096 \pm 0.00013$ (2σ , $n = 33$), or a repeatability under measurement conditions (repeatability) of ~0.8 ‰. This mean $^{187}\text{Os}/^{188}\text{Os}$ overlaps with the accepted value of 0.160924 ± 0.00004 (Luguet et al., 2008) within 2σ and we consider the data accurate at this level of precision.

PGE and Re abundances were measured on either an Element 2 ICP-MS or Nu Attom ICP-MS at the ARGL. Mass fractionation was corrected externally using synthetic 1 ppb PGE standards. The mass fractionation-corrected isotopic composition of these standards show repeatability of ~0.4 % for Re, ~0.6 % for Ru, and ~0.8 % for Pd, Ir, and Pt (2σ). We take these values as the maximum precision on an individual isotopic measurement. Blank corrections based on the long term average blanks ($n = 10$; Table 1) were made for all abundance and isotopic analyses. Blanks constitute $\leq 1.1\%$ of the total mass analysed for Os, Ir, and Ru, for both whole rock and leached chromite samples, and $< 5\%$ of the total mass analysed for Pd and Pt, and Re in whole rocks. However, due to small sample sizes of the leached chromites and low concentrations, the blank comprises up to 22%, 38%, and 79% of the total mass analysed for Pd, Pt, and Re, respectively. As a result, Pt and

Pd analyses are relatively imprecise and all Re analyses are below the LOD (limit of detection) in the leached chromites. Accuracy of the PGE abundance measurements (including Os) was monitored through repeat analyses of the OKUM standard. The intermediate precision is better than 17% (2 relative standard deviations, $n = 50$) for all PGEs and Re, which includes uncertainty from powder heterogeneity (Table DR2). Our data overlaps previously published data for the OKUM standard within 2σ , and we consider the data accurate at this level of precision.

Bulk rock quartzites have IPGE patterns similar to, but with much lower concentrations than, the leached chromite separates. We interpret this as dilution of the pure chromite signal predominantly by PGE-poor quartz. However, Pt and Pd concentrations are similar to, and Re concentrations are much higher than in the chromites. This may represent the sedimentation of Pt, Pd and Re enriched minerals in the quartzite, or metamorphic mobility of these elements, which tend to be more mobile than the IPGEs (Dale et al., 2009). Bulk rock samples returned meaningless future rhenium depletion ages (T_{RD} ; ^{187}Os model ages for separation from an O-chondrite source assuming zero radiogenic Os ingrowth; Table DR2), though one bulk rock rhenium maximum age (T_{MA}) age of 3.12 Ga was indistinguishable from the leached chromite T_{RD} ages.

Unleached chromite samples returned Proterozoic T_{RD} ages and had PGE patterns with strongly elevated Re and Pd relative to the leached chromite samples. This is believed to represent the inclusion of Re- and Pd-rich material from either the host quartzite or metamorphic fluids, and these samples are not considered further in this study.

Re-Os model ages

The weighted mean T_{RD} age for the four leached chromite separates (3.19 ± 0.06 Ga; 2σ , MSWD = 0.06, $p = 0.98$) was calculated using Isoplot (Ludwig, 2012).

All T_{RD} and T_{MA} model ages presented in the main text and in table DR2 are calculated using an ordinary chondrite (O-chondrite) reference model for Earth's mantle (Walker et al., 2002). However, significant uncertainties exist in the Re-Os isotopic composition of the Earth's mantle, which introduces a model dependent systematic uncertainty into the Re-Os ages. We address this model-dependency by recalculating the T_{RD} and T_{MA} ages using different models for the Re-Os evolution of the Earth's mantle. For ~ 3.2 Ga rocks, use of an enstatite chondrite model (E-chondrite; Walker et al., 2002) produces T_{RD} and T_{MA} ages ~ 20 Ma younger than O-chondrite; use of a carbonaceous chondrite (C-chondrite; Walker et al., 2002) model produces T_{RD} and T_{MA} ages ~ 30 Ma younger than O-chondrite; use of a primitive upper mantle (PUM; Meisel et al., 2001; Walker et al., 2002) produces T_{RD} and T_{MA} ages ~ 170 Myrs older than O-chondrite. We treat this 200 Ma age range in mantle models as a ± 100 Ma 2σ uncertainty, and propagate this uncertainty in quadrature into the weighted mean age. This gives a weighted mean age including systematic uncertainty of 3.19 ± 0.12 Ga.

Rhenium contents for all leached chromite separates were below the LOD of 7 pg. However, due to the small masses of chromite analysed, undetectable levels of Re still have the potential to affect T_{RD} model ages for the chromite separates. We assess the potential impact of undetected Re on model ages by recalculating leached chromite separate ages as T_{MA} ages, using $\text{Re} = \text{LOD}$. For samples with mass ~ 0.1 g, this corresponds to a Re-concentration of 0.067 ppb. The leached chromite T_{MA} ages calculated with $\text{Re} = \text{LOD}$ are compared to the T_{RD} ages in Table DR3.

Unlike the T_{RD} ages, T_{MA} calculated using $Re = LOD$ are highly scattered, as the different Os concentrations lead to varying T_{MA} ages, even for samples with identical present day $^{187}Os/^{188}Os$ and assumed Re concentrations. The age data do not define a single population, with T_{MA} ranging from 3.47 Ga to 3.73 Ga and a low probability of fit (weighted mean = 3.53 ± 0.17 Ga; 2σ , MSWD = 2.88, $p = 0.03$). If these ages are taken at face value, it would require that there were multiple generations of chemically identical chromite in the sedimentary sources of the Bell Lake and Dwyer Lake quartzites, formed over a wide time span of ~ 250 Ma. Furthermore, each of these different chromite sources would require the precise Re/Os ratios to produce statistically indistinguishable $^{187}Os/^{188}Os$ ratios at the present day, corresponding to a 3.19 Ga T_{RD} age. Though the case of $Re = LOD$ is a worst case scenario, this example illustrates the effect of any significant level of undetected Re in the chromite separates, requiring Re/Os to vary with Os concentrations to produce identical present day $^{187}Os/^{188}Os$. We conclude that it is very unlikely that ^{187}Os ingrowth from Re decay had any significant effect on the $^{187}Os/^{188}Os$ ratios (at the stated level of precision of the T_{RD} ages), and that the chromites formed at ~ 3.19 Ga.

Figure DR1. (A) Locality map showing the Bell and Dwyer Lakes. (B) Outcrop map from the Bell Lake location and (C) from Dwyer Lake. UTM coordinates for RHNWT-14A: 11V 635980 6970960 and RHNWT-3A: 11V 637227 6953353. Map in (A) modified from Stubley (2005). Bell Lake outcrop map modified from Jackson (1998). Dwyer Lake outcrop map modified from MacLachlan and Helmstaedt (1993) and Isachsen and Bowring (1997).

Figure DR1 continued. Representative field photos showing key bedrock localities from the fuchsitic quartzite within the CSCG. (D) The unconformable contact between the CSBC and CSCG at Dwyer Lake. (E) A ca. 5 m exposure of the fuchsitic quartzite just above the basement contact in (D). Inset photo shows black heavy mineral lamination with green colored fuchsite. (F) Close-up photo from Bell Lake illustrating the lamination of fuchsite and heavy mineral seams within otherwise white/greyish quartzite. (G) Sample site of the fuchsitic quartzite at Bell Lake with the outcrop having high-density of detrital chromite laminae.

Figure DR2. (A) Backscattered microprobe image of a representative chromite grain with a transect consisting of 10 spot analyses. Other mineral phases are rutile, fuchsite (Cr-mica) and quartz (qtz). (B) Major oxide (wt.%) histograms from the grain transect in (A). Where Cr₂O₃ and Al₂O₃ are very uniform distributed throughout the chromite, a weak zonation is seen for ZnO with elevated values towards the grain edges. This is compensated by a reverse pattern for FeO, and partly MgO and MnO.

Figure DR3. Representative time-series spectra (time vs. cps) of PGEs in chromite grains obtained with a 130 μm in diameter laser beam. A typical uniform pattern of Os, Ir, Ru and Pd suggesting that IPGE's and PPGE's are in solid solution in the chromite crystal structure and that the chromite grains crystallized from a komatiite magma rather than a komatiitic basalt (e.g., Fiorentini et al., 2004; Locmelis et al., 2011; Pagé et al., 2012). Osmium and Ruthenium was only detectable in part of the grains whereas Pt was below detection in all the grains analyzed. See method section for details.

Table DR1. Electron microprobe analysis of the detrital chromite grains from the CSCG (RHNWT-3A = Dwyer Lake; RHNWT-14A = Bell Lake). Cr# = Cr/(Cr+Al); Mg# = Mg/(Mg+Fe²⁺). *Fe₂O₃ is stoichiometric calculated (Droop, 1987)

analyses	SiO ₂	TiO ₂	Al ₂ O ₃	FeO	Fe ₂ O ₃ *	Cr ₂ O ₃	MgO	MnO	NiO	ZnO	Total	Cr#	Mg#
RHNWT-3A													
1 (center)	0.14	0.37	15.73	21.50	3.67	44.05	0.33	1.73	0.06	12.09	99.66	0.65	0.03
2	0.10	0.21	15.16	22.40	3.7	44.95	0.36	1.58	0.05	10.79	99.31	0.67	0.03
3	0.09	0.27	16.16	20.64	1.87	45.20	0.30	1.66	0.02	12.94	99.15	0.65	0.03
4	0.12	0.28	16.3	20.46	1.89	44.93	0.27	1.76	0.03	13.16	99.21	0.65	0.02
5	0.11	0.29	15.54	21.58	3.37	44.73	0.27	1.82	0.03	11.86	99.60	0.66	0.02
6	2.30	0.20	15.32	21.44	0	42.27	0.47	1.51	0.04	10.72	94.29	0.65	0.04
7	0.10	0.31	17.63	20.49	1.79	43.56	0.34	1.65	0.02	13.4	99.30	0.62	0.03
8	0.13	0.38	16.96	19.92	1.39	44.74	0.35	1.58	0.02	14.21	99.68	0.64	0.03
9	0.11	3.60	18.43	22.37	0	41.32	0.53	1.33	0.00	11.88	99.57	0.60	0.04
10	0.19	0.32	16.62	21.45	3.47	43.10	0.38	1.56	0.05	12.36	99.50	0.63	0.03
11	0.18	0.29	15.02	22.70	2.76	45.81	0.36	1.64	0.05	10.62	99.42	0.67	0.03
12	0.10	0.29	14.97	21.16	4.16	44.35	0.26	1.77	0.06	12.1	99.21	0.67	0.02
13	0.12	0.26	15.39	21.74	2.87	45.09	0.28	1.72	0.04	11.52	99.02	0.66	0.02
14	0.12	0.24	15.32	22.42	2.23	45.97	0.34	1.73	0.03	10.72	99.12	0.67	0.03
15	0.12	0.22	18.39	21.99	2.14	42.52	0.39	1.6	0.04	11.74	99.15	0.61	0.03
16	0.12	0.38	19.28	21.91	2.9	40.27	0.42	1.43	0.05	12.14	98.90	0.58	0.03
17	0.31	0.20	19.14	21.62	0.64	42.14	0.42	1.53	0.03	12.27	98.30	0.60	0.03
18	0.24	0.39	13.54	19.87	1.21	48.29	0.21	1.8	0.03	13.69	99.26	0.71	0.02
19	0.12	0.24	17.31	19.20	1.6	43.89	0.31	1.63	0.01	14.69	99.00	0.63	0.03
Average	0.25	0.46	16.43	21.31	2.19	44.06	0.35	1.63	0.03	12.26	-	0.64	0.03
RHNWT-14A													
20 (edge)	0.13	0.25	16.65	20.57	2.27	44.11	0.38	1.61	0.05	12.97	98.99	0.64	0.03
21	0.11	0.23	15.88	21.31	3.01	44.90	0.35	1.56	0.04	12.34	99.73	0.65	0.03
22	0.12	0.25	16.24	21.17	1.88	45.26	0.29	1.65	0.04	12.48	99.39	0.65	0.02
23	0.14	0.29	15.84	20.16	2.37	44.78	0.24	1.76	0.04	13.42	99.04	0.65	0.02
24	0.11	0.26	16.34	20.44	2	44.92	0.26	1.73	0.04	13.23	99.33	0.65	0.02
25	0.11	0.22	17.17	19.16	2.5	43.40	0.35	1.51	0.04	14.78	99.24	0.63	0.03
26	0.13	0.32	17.62	20.52	1.98	43.51	0.36	1.57	0.04	13.57	99.61	0.62	0.03
27	0.16	0.14	17.02	19.79	1.51	44.73	0.33	1.57	0.01	14.13	99.38	0.64	0.03
28	0.20	0.65	19.68	21.61	0	41.62	0.47	1.36	0.02	11.93	97.53	0.59	0.04
29	0.18	0.32	17.71	20.14	1.9	43.42	0.31	1.62	0.04	14.14	99.77	0.62	0.03
30	0.18	0.21	14.71	22.23	3.06	45.84	0.29	1.74	0.03	10.96	99.24	0.68	0.02
31	0.12	0.26	15.17	20.41	4.15	44.44	0.28	1.7	0.04	13.18	99.75	0.66	0.02
32	0.15	0.25	15.65	21.52	2.71	45.23	0.29	1.71	0.04	12.05	99.60	0.66	0.02
33	0.15	0.25	15.25	21.67	2.32	45.87	0.34	1.71	0.03	11.6	99.19	0.67	0.03
34	0.12	0.18	18.47	21.48	1.96	42.44	0.41	1.59	0.04	12.1	98.79	0.61	0.03
35	0.12	0.34	18.51	21.46	4.07	40.10	0.39	1.52	0.07	12.42	99.00	0.59	0.03
36	0.12	0.16	18.53	19.81	1.67	42.60	0.43	1.53	0.02	14.04	98.90	0.61	0.04
37	0.20	0.42	13.67	19.57	1.53	47.91	0.20	1.76	0.03	14.13	99.42	0.70	0.02
38	0.11	0.09	17.6	18.13	1.9	43.67	0.27	1.61	0.05	15.89	99.32	0.62	0.03
Average	0.14	0.27	16.72	20.59	2.25	44.14	0.33	1.62	0.04	13.12	-	0.64	0.03

Table DR1 continued.

<i>analyses</i>	SiO ₂	TiO ₂	Al ₂ O ₃	FeO	Fe ₂ O ₃ [*]	Cr ₂ O ₃	MgO	MnO	NiO	ZnO	Total	Cr#	Mg#
RHNWT-14A													
1 (center)	0.12	0.23	15.45	23.50	4.52	44.07	0.48	1.8	0.04	9.33	99.53	0.66	0.03
2	0.12	0.28	14.39	23.81	4.29	45.43	0.45	1.8	0.06	8.89	99.52	0.68	0.03
3	0.09	0.25	17.07	20.42	3.49	43.27	0.37	1.46	0.02	13.76	100.20	0.63	0.03
4	0.08	0.46	17.64	20.91	5.69	40.30	0.42	1.5	0.06	13.39	100.44	0.61	0.03
5	0.08	0.27	13.67	21.50	5.69	44.87	0.38	1.67	0.05	11.53	99.70	0.69	0.03
6	0.10	0.20	18.68	19.92	3.01	41.66	0.44	1.41	0.03	14.34	99.79	0.60	0.04
7	0.15	0.33	15.46	23.83	5.91	42.34	0.44	1.75	0.02	9.18	99.41	0.65	0.03
8	0.14	0.22	14.4	21.66	4.31	45.45	0.45	1.7	0.07	11.39	99.78	0.68	0.04
9	0.10	0.41	15.7	22.36	6.5	41.39	0.48	1.65	0.06	10.86	99.50	0.64	0.04
10	0.37	0.30	20.75	20.69	1.61	39.92	0.45	1.36	0.01	14.43	99.90	0.56	0.04
11	0.11	0.32	14.05	21.55	6.07	44.08	0.36	1.67	0.04	11.74	100.00	0.68	0.03
12	0.11	1.00	18.59	20.92	2.04	40.87	0.40	1.39	0.02	13.99	99.32	0.60	0.03
13	0.14	0.26	13.56	21.59	5.23	45.60	0.35	1.71	0.04	11.67	100.15	0.69	0.03
14	0.13	0.29	14.4	21.56	3.77	45.84	0.35	1.61	0.04	11.88	99.86	0.68	0.03
15	0.10	0.42	16.24	20.48	5.32	41.84	0.38	1.45	0.04	13.52	99.81	0.63	0.03
16	0.17	0.38	16.71	21.59	5.49	41.44	0.49	1.61	0.04	12.23	100.15	0.62	0.04
17	0.07	0.25	16.13	20.15	7.09	40.70	0.41	1.5	0.02	13.6	99.92	0.63	0.03
18	0.07	0.28	13.83	21.55	5.4	45.02	0.44	1.67	0.05	11.38	99.69	0.69	0.04
19	0.08	0.12	17.65	20.19	2.82	43.00	0.41	1.46	0.02	13.62	99.37	0.62	0.03
20	0.09	0.28	14.85	23.56	4.52	44.68	0.45	1.82	0.04	9.17	99.46	0.67	0.03
21	0.28	0.32	16.65	23.93	5.17	41.28	0.44	1.73	0.04	9.43	99.26	0.62	0.03
22	0.12	0.21	17.55	20.36	2.56	43.26	0.40	1.42	0.03	13.7	99.61	0.62	0.03
Average	0.13	0.32	16.06	21.64	4.57	43.01	0.42	1.60	0.04	11.96	-	0.64	0.03
23 (edge)	0.08	0.25	15.41	23.26	4.66	44.35	0.50	1.82	0.07	9.64	100.04	0.66	0.04
24	0.10	0.28	14.41	23.67	4.55	45.24	0.48	1.82	0.04	8.97	99.55	0.68	0.03
25	0.10	0.27	17.75	20.72	5.23	40.34	0.37	1.49	0.05	13.27	99.59	0.60	0.03
26	0.09	0.26	15.75	23.58	5.73	42.51	0.40	1.73	0.02	9.49	99.56	0.64	0.03
27	0.09	0.32	15.07	20.72	3.96	44.91	0.31	1.52	0.02	13.1	100.03	0.67	0.03
28	0.08	0.41	15.89	21.95	6.5	41.37	0.44	1.63	0.04	11.55	99.86	0.64	0.03
29	0.10	0.49	18.92	20.08	2.47	41.36	0.37	1.41	0.04	14.63	99.87	0.59	0.03
30	0.12	0.28	13.33	21.47	5.4	45.72	0.34	1.67	0.04	11.79	100.16	0.70	0.03
31	0.11	0.38	16.44	20.31	5.35	42.03	0.35	1.48	0.06	13.94	100.44	0.63	0.03
32	0.11	0.34	15.7	23.22	6.28	41.81	0.44	1.76	0.03	9.85	99.54	0.64	0.03
33	0.11	0.28	14.88	23.60	4.47	44.98	0.46	1.83	0.05	9.27	99.95	0.67	0.03
34	0.06	0.25	17.54	20.02	2.8	43.14	0.38	1.44	0.04	14.08	99.75	0.62	0.03
35	0.05	0.30	13.8	21.35	5.45	44.86	0.36	1.63	0.03	11.73	99.55	0.69	0.03
36	0.12	0.35	17.05	20.59	3.09	43.16	0.32	1.46	0.03	13.63	99.79	0.63	0.03
37	0.10	0.90	18.67	20.39	2.04	41.40	0.40	1.41	0.02	14.66	99.99	0.60	0.03
38	0.11	2.26	19.68	21.57	0.11	39.27	0.38	1.291	0.03	14.94	99.65	0.57	0.03
39	0.10	0.31	14.27	21.53	6.08	43.73	0.36	1.62	0.04	11.76	99.81	0.67	0.03
40	0.10	0.28	14.36	21.36	3.99	45.81	0.37	1.63	0.06	12	99.96	0.68	0.03
41	0.23	0.38	17.41	21.72	4.56	40.99	0.44	1.55	0.05	12.22	99.54	0.61	0.03
42	0.07	0.38	16.37	20.27	6.88	40.49	0.42	1.48	0.03	13.67	100.07	0.62	0.04
Average	0.10	0.45	16.14	21.57	4.48	42.87	0.39	1.58	0.04	12.21	-	0.64	0.03
Grain transect													
Spot 1	0.03	0.35	15.95	20.21	4.79	42.90	0.34	1.49	0.04	13.62	99.73	0.64	0.03
Spot 2	0.04	0.27	15.74	20.58	5.05	42.87	0.35	1.54	0.02	12.92	99.38	0.65	0.03
Spot 3	0.02	0.27	15.73	20.78	5.23	42.84	0.40	1.59	0.06	12.53	99.46	0.65	0.03
Spot 4	0.05	0.27	15.78	21.05	5.12	43.08	0.42	1.6	0.06	12.37	99.80	0.65	0.03
Spot 5	0.03	0.29	15.82	21.25	4.9	43.00	0.43	1.6	0.04	12.01	99.38	0.65	0.04
Spot 6	0.02	0.33	15.94	20.92	5.35	42.71	0.47	1.62	0.05	12.5	99.91	0.64	0.04
Spot 7	0.03	0.26	15.89	21.07	5.09	42.86	0.46	1.61	0.06	12.14	99.47	0.64	0.04
Spot 8	0.03	0.26	15.87	20.93	5.19	42.95	0.44	1.64	0.06	12.37	99.73	0.64	0.04
Spot 9	0.03	0.28	15.87	20.57	5.33	42.89	0.43	1.55	0.04	12.99	99.98	0.64	0.04
Spot 10	0.06	0.33	16.53	20.41	4.12	42.80	0.34	1.48	0.03	13.5	99.60	0.63	0.03

Table DR2. PGE chemistry and Re-Os isotope results of the detrital chromite grains from the CSCG. Limits of detection expressed as concentrations vary according to sample mass, therefore LODs are given for both 0.1 gram and 2 gram sample masses. Average OKUM PGE concentrations analysed at the ARGL are compared to existing literature data. The Re-Os model ages are calculated using the O-chondrite mantle model (Walker et al., 2002). The consistent and low Re/Os ratio makes it possible to establish robust T_{RD} model ages of the chromite separates between 3.17 and 3.21 Ga.

Sample ID	Type	PGE concentrations (ppb)													
		mass (g)	Os	2σ abs.	Ir	2σ abs.	Ru	2σ abs.	Pt	2σ abs.	Pd	2σ abs.	Re	2σ abs.	
Samples															
chr-3A-1	unleached chromite	0.12567	N/A	N/A	12.28	0.27	N/A	N/A	0.81	0.03	2.58	0.07	0.174	0.012	
chr-14A-1	unleached chromite	0.38190	13.16	0.09	12.95	0.27	N/A	N/A	1.65	0.06	5.89	0.17	0.163	0.029	
chr-3A-2	leached chromite	0.10133	5.20	0.35	5.65	0.05	12.22	0.15	1.06	0.26	1.15	0.17	<LOD		
chr-14A-2a	leached chromite	0.10282	8.02	0.35	7.98	0.07	20.59	0.23	0.67	0.26	0.23	0.12	<LOD		
chr-14A-3	leached chromite	0.10318	5.57	0.34	5.82	0.06	9.08	0.16	0.42	0.26	0.37	0.13	<LOD		
chr-14A-2b	leached chromite	0.10088	9.24	0.37	9.02	0.08	12.86	0.20	0.98	0.27	0.24	0.14	<LOD		
RHNWT-3A	whole rock	1.98409	0.19	0.01	0.21	0.00	0.44	0.01	0.75	0.02	0.14	0.01	0.041	0.002	
RHNWT-14A	whole rock	2.03544	0.57	0.01	0.46	0.01	1.67	0.02	0.86	0.02	0.50	0.01	0.223	0.006	
LODs															
LOD 0.1 g samples			0.12		0.04		0.10		0.40		0.14		0.07		
LOD 2 g samples			0.006		0.002		0.005		0.020		0.007		0.003		
OKUM standard															
Average ARGL (N = 50)			0.80	0.14	0.90	0.14	4.53	0.55	11.6	1.1	11.4	1.2	0.507	0.061	
2σ rel. uncertainty			17%		15%		12%		10%		10%		12%		
Geo Labs (2001)					0.99	0.14	4.25	0.60	11.00	0.60	11.70	0.50			
Barnes & Fiorentini (2008)					1.05	0.14	4.20	1.00	11.60	0.60	11.80	0.60			
Maier et al. (2009)			0.83	0.12	1.00	0.12	4.29	0.62	10.40	0.68	11.43	1.64			
Savard et al. (2010)			0.98	0.68	1.00	0.26	4.33	1.06	11.00	0.58	11.35	1.58			
Savard et al. (2010)			0.79		0.94	0.08	4.14	0.16	11.44	0.44	12.20	1.46	0.57	0.08	

Sample ID	Type	mass (g)	Re-Os isotopic data							
			$^{187}\text{Re}/^{188}\text{Os}$	2 σ abs.	$^{187}\text{Os}/^{188}\text{Os}$	2 σ abs.	O-chon TRD (Ma)	2 σ abs.	O-chon TMA (Ma)	2 σ abs.
Samples										
chr-14A-1	unleached chromite	0.38190	0.060	0.011	0.11239	0.00010	2221	15	2578	76
chr-3A-2	leached chromite	0.10133	N/A	N/A	0.10513	0.00125	3207	169	N/A	N/A
chr-14A-2a	leached chromite	0.10282	N/A	N/A	0.10573	0.00024	3174	102	N/A	N/A
chr-14A-3	leached chromite	0.10318	N/A	N/A	0.10570	0.00039	3198	148	N/A	N/A
chr-14A-2b	leached chromite	0.10088	N/A	N/A	0.10553	0.00019	3196	90	N/A	N/A
RHNWT-3A	whole rock	1.98409	1.064	0.043	0.17654	0.00021	N/A	N/A	4548	500
RHNWT-14A	whole rock	2.03544	1.918	0.055	0.20751	0.00025	N/A	N/A	3115	119

Table DR3. Comparison of TRD ages for leached chromite separates with TMA ages calculated assuming Re concentrations are equal to the limit of detection. Weighted means, MSWD and probability of fit are calculated using Isoplot (Ludwig 2012).

	TRD age	2 σ	TMA with Re=LOD	2 σ
chr-3A-2	3207	169	3730	200
chr-14A-2a	3174	102	3487	113
chr-14A-3	3198	148	3670	173
chr-14A-2b	3196	90	3472	98
Weighted mean	3190	58	3531	174
MSWD	0.06		2.88	
Probability of fit	98%		3%	

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