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Early continental crust generated by reworking of basalts variably silicified by seawater

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Documents provided as supplementary information to

"EARLY CONTINENTAL CRUST GENERATED BY REWORKING OF BASALTS VARIABLY SILICIFIED BY SEAWATER"

by Luc André, Kathrin Abraham, Axel Hofmann, Laurence Monin, Ilka C. Kleinhanns and Stephen Foley

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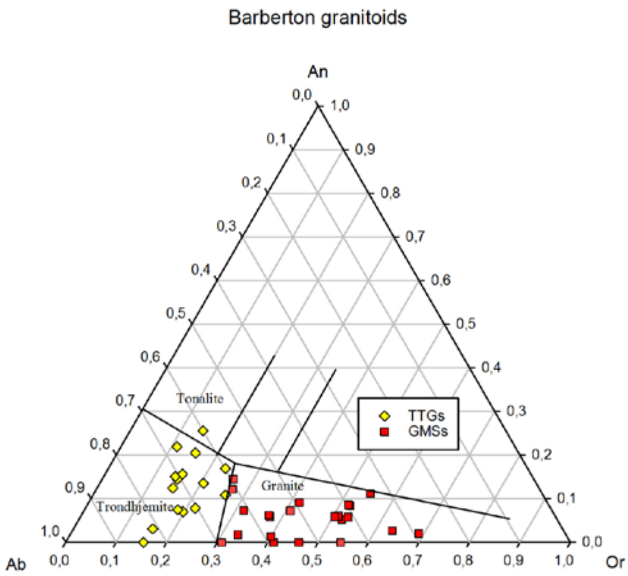

Supplementary Figure 1: Normative Ab-An-Or compositions of the analysed whole-rocks. The three granites that plot very close to the boundary between the trondhjemitic and granitic fields correspond to two specimens from the Dalmein pluton (Bar-10 & 99/108) and one sample from the Nelspruit pluton (99/118).

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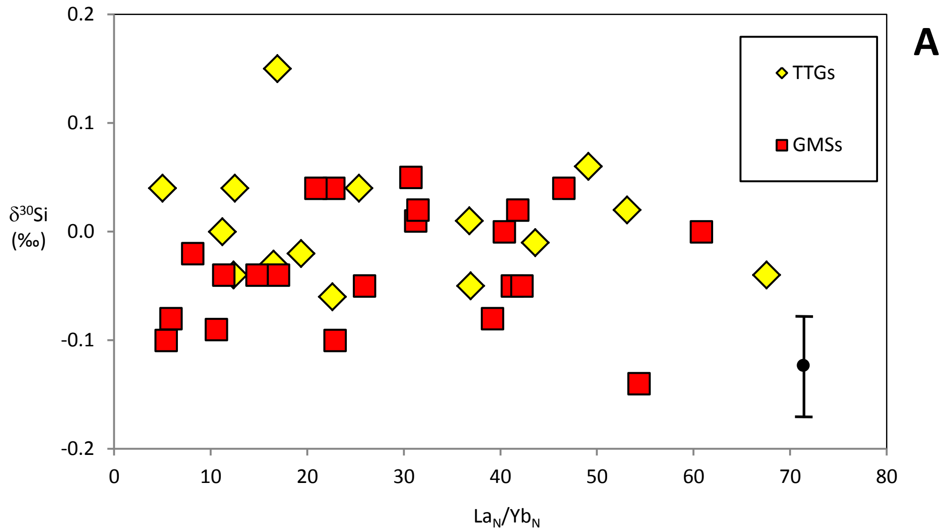
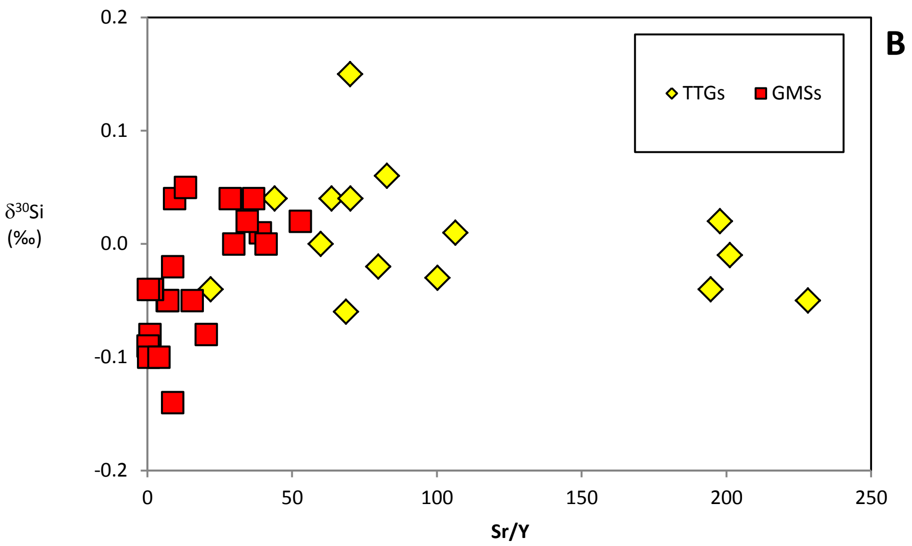


Supplementary Figure 2A: δ^{30}Si-La_N/Yb_N diagram for the TTGs and GMSs. The error bar corresponds to $2\sigma_{\bar{x}}$ error (± 0.05‰) on δ^{30}Si (See Methods)



Supplementary Figure 2B: δ^{30}Si-Sr/Y diagram for the TTGs and GMSs.

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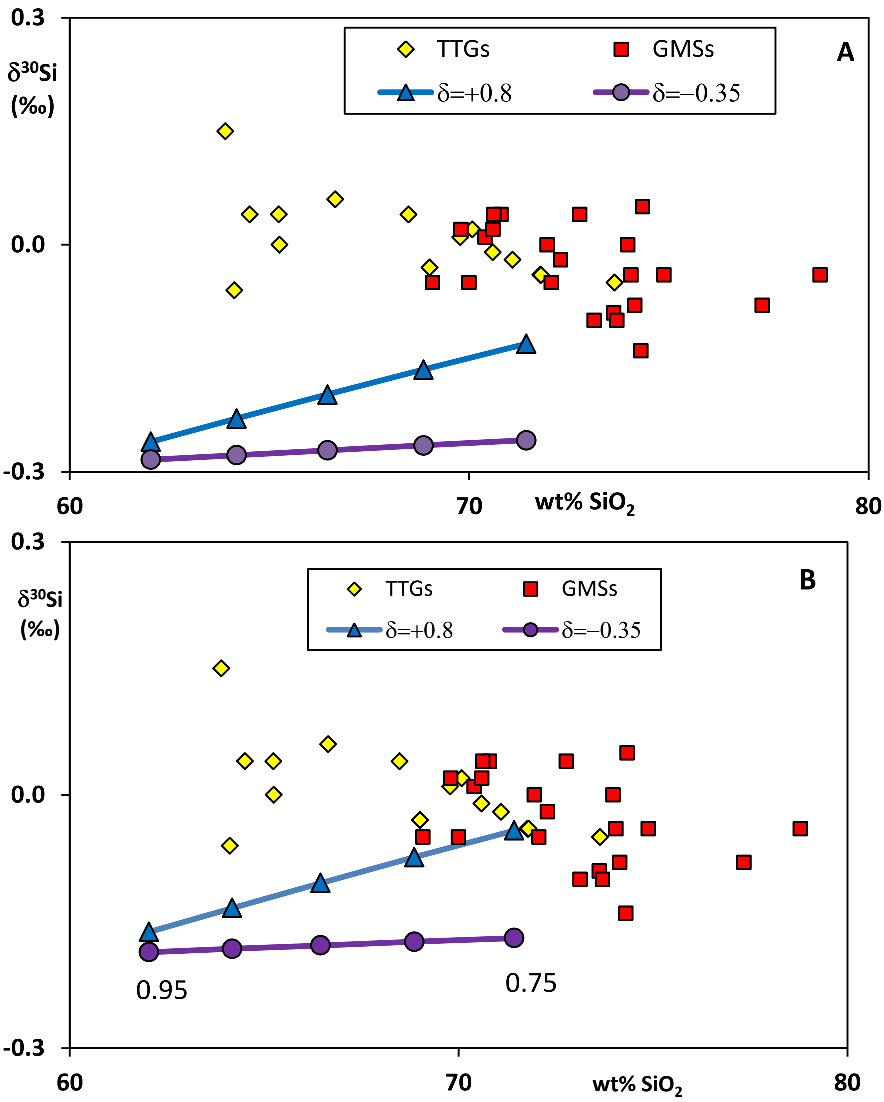
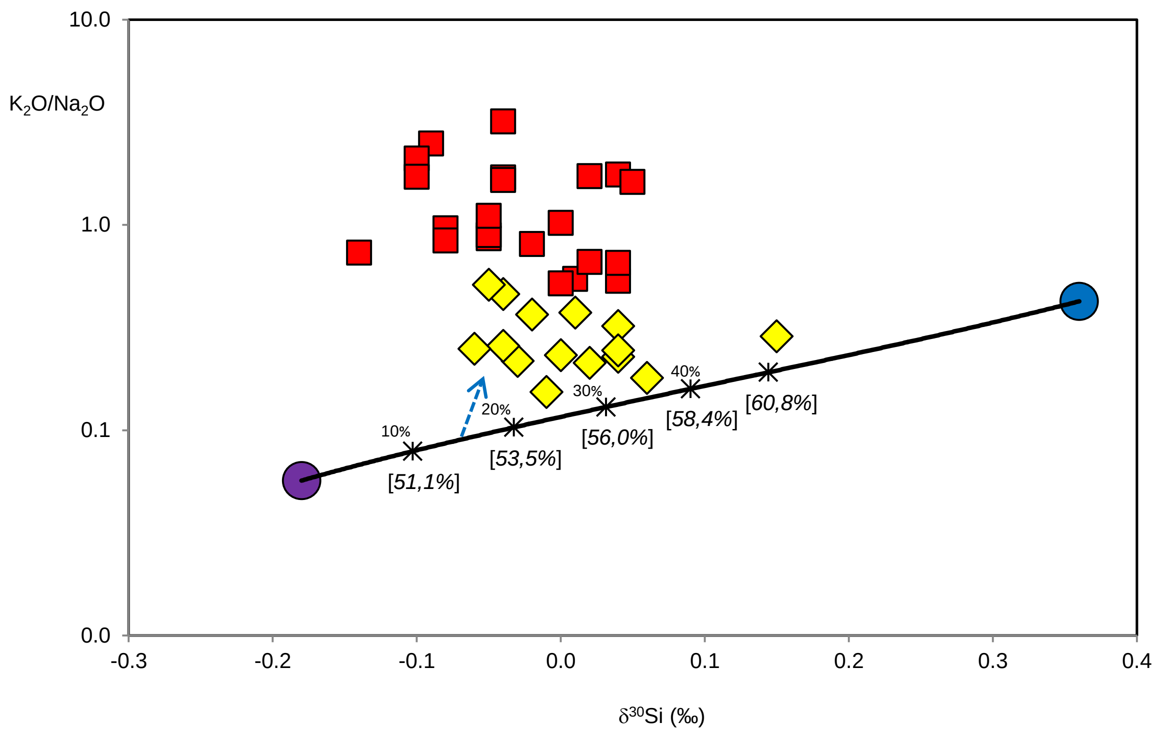
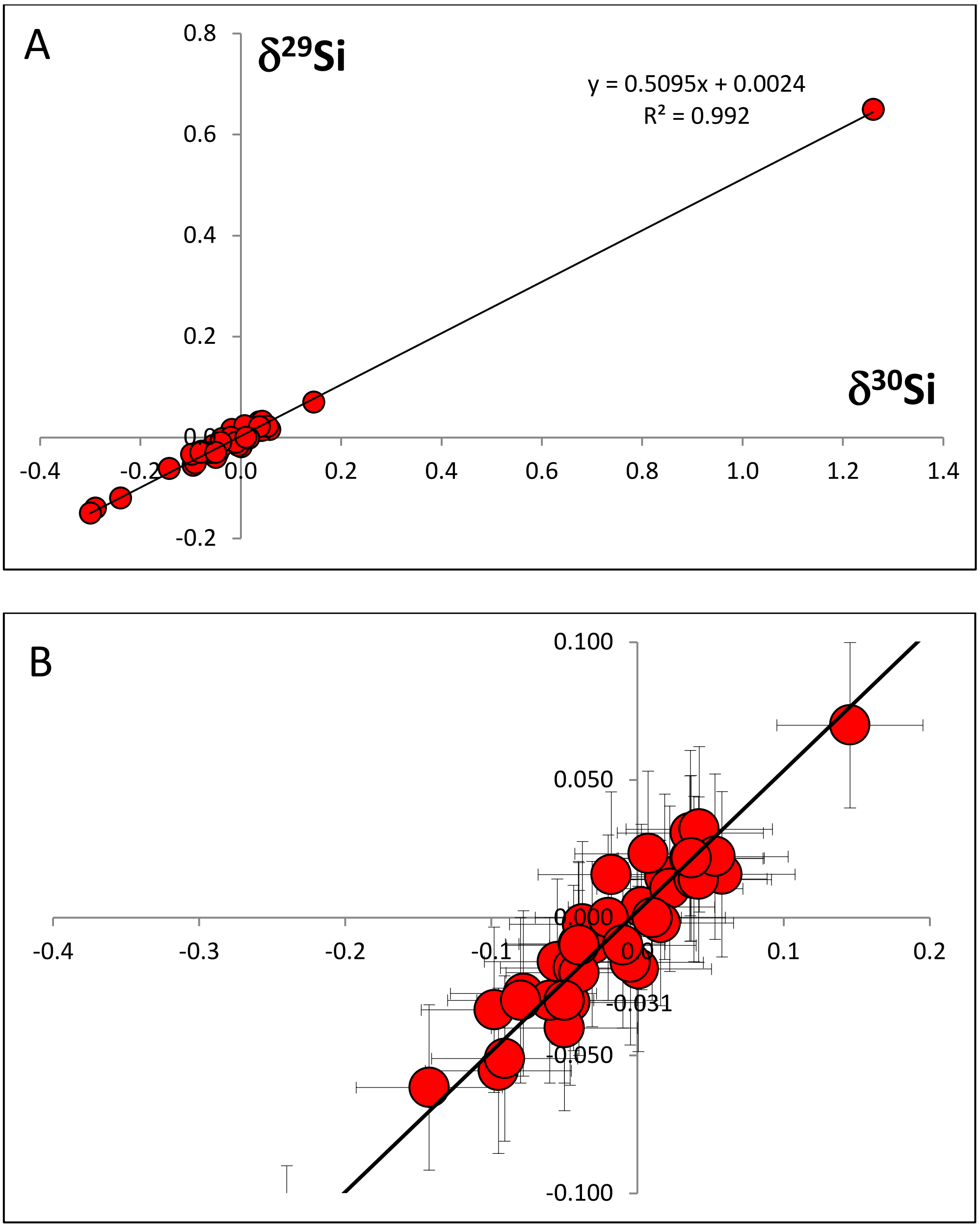


Supplementary Figure 3: Combined Assimilation and Fractional Crystallization (AFC) models for the assimilation of chert by a parental TTG melt compared to the Barberton TTGs and GMSs using De Paolo's equations[31]. A. The TTG parental melt keeps a signature close to its basaltic parent (δ^{30}Si =-0.29‰). **B.** The TTG parental melt bears a heavier signature (δ^{30}Si =-0.19‰) than its basaltic parent due to a minor melt-restite Si isotopic fractionation factor ($\Delta_{melt\text{-}restite}$=+0.1‰). Models have been calculated for a maximal low-pressure ratio of assimilated *versus* fractionated mass fractions (r=0.3)[31], assuming a low silica (60wt%) parental TTG melt and an average local chert contaminant (95wt%). Moyen and Martin (2012) have pointed out that: (1) low pressure fractional crystallisation of the parental TTG operates by extraction of a hornblende ± plagioclase assemblage and (2) the degree of crystal segregation is in all cases lower than 25%. Hence the fraction of melt remaining has been supposed to vary between 0.95 and 0.75 (circles and triangles on the curves, one symbol every 5%) and we have considered bulk crystal/melt partition for silica (D_{SiO2}=0.7) and Si isotopes (Δ^{30}Si =-0.1‰) reflecting such a hornblende ± plagioclase (2:1) assemblage. Calculations were performed for the extreme silicon isotopic compositions of the local Barberton cherts (δ^{30}Si =+0.8 and -0.35‰). Obviously most Barberton TTGs plot outside the AFC curves. This clearly rules out a supracrustal chert assimilation as a mechanism to account for the TTG heavy silicon isotopic signatures.

Moyen, J-F. & Martin, H. Forty years of TTG research. *Lithos* 148, 312-336 (2012).



Supplementary Figure 4: K_2O/Na_2O *versus* $\delta^{30}Si$ plot for the TTGs (yellow diamonds) and GMSs (red squares). Model is calculated for mixtures between the average composition of unsilicified (purple circle) and silicified (blue circle) metabasalt of the Theespruit Formation. Ticks and numbers above the mixing curve indicate the proportion of silicified material in the mixtures (one tick every 10%). Figures in brackets below the curve give the silica contents (in wt%) of the mixtures. Considering that both K_2O/Na_2O[33,38] and $\delta^{30}Si$[9,10,11] should increase slightly in partial melts relative to their source-rocks under equilibrium conditions (as symbolised by the blue dashed arrow), mixtures including about 15-35% of Theespruit-like silicified metabasalts could account for both K_2O/Na_2O and $\delta^{30}Si$ values in the TTG granitoids. More strongly silicified metabasalts in the source might cause much larger K_2O/Na_2O ratios in the produced melt because: (1) silicified metabasalts have higher K_2O/Na_2O than their unsilicified counterparts (See also Supplementary Table 3) and (2) larger quantities of silica in the source (> 60wt%) induce granitic like melts with higher K_2O/Na_2O[38]. Such highly silicified sources might be the protoliths for the older GMSs characterised by heavier $\delta^{30}Si$ (>0‰).



Supplementary Figure 5: A. Three isotope plot for the granitoid rocks and the GA, BHVO-1, BHVO-2 and diatomite standards. They fit a line of δ^{29}Si=0.5095xδ^{30}Si; **B.** Enlargement around the granitoid data showing that they all fit this line within uncertainties (±0.03‰ and ±0.05‰ for δ^{29}Si and δ^{30}Si, respectively).

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Supplementary Table 1: Geographic coordinates of the sampling sites

Sample	Pluton	Latitude	Longitude
99/109	Steynsdorp	26°10'33'' S	30°59'51'' E
99/122	Steynsdorp	26°11'00'' S	30°40'34'' E
Bar-6	Steynsdorp	25°09'13''S	30°57'20'' E
99/120	Stolzburg	26°01'27'' S	30°45'41'' E
Bar-2	Stolzburg	26°01'28''S	30°45'42'' E
99/107	Theespruit	26°02'00'' S	30°50'31'' E
99/121	Theespruit	26°03'00'' S	30°51'46'' E
Bar-3	Theespruit	26°01'25''S	30°48'07'' E
Bar-5	Badplaas	25°57'44''S	30°35'24'' E
99/106	Nelshoogte	25°51'06'' S	30°41'59'' E
Bar-9	Nelshoogte	25°53'29''S	30°37'24'' E
Bar-8	Kaap Valley	25°44'06''S	31°04'10'' E
Bar-10	Dalmein	26°05'24''S	30°56'17'' E
99/108	Dalmein	26°04'54'' S	30°55'58'' E
99/118	Nelspruit	25°29'30'' S	31°11'00'' E
99/110	Nelspruit	25°33'56'' S	30°58'14'' E
99/112	Nelspruit	25°31'20'' S	31°19'53'' E
99/119	Nelspruit	25°23'34'' S	30°58'52'' E
Bar11	Nelspruit	25°27'29'' S	31°01'02'' E
Bar12	Mpageni	25°30'56''S	31°13'43'' E
99/111	Mpageni	25°30'41'' S	31°12'47'' E
Bar14	Piggs Peak	25°57'25''S	31°16'29'' E
Bar15	Piggs Peak	26°07'12''S	31°10'19'' E
99/115	Salisbury Kop	25°27'27'' S	31°37'34'' E
Bar13	Salisbury Kop	25°29'01''S	31°40'32'' E
99/117	Stentor Pluton	25°37'04'' S	31°18'23'' E
Bar-7	Stentor	25°37'03''S	30°18'24'' E
99/126	Mpuluzi	26°09'17'' S	30°51'36'' E
99/127	Mpuluzi	26°12'37'' S	30°35'04'' E
Bar-1	Mpuluzi	26°12'36'' S	30°35'04'' E
SINC1	Sinceni	26°46'07''S	31°29'32'' E
SINC2	Sinceni	26°50'38''S	31°29'38'' E
SW5-1	Nhlangano	27°01'43''S	31°14'01'' E
MG18	Ncotshane	27°17'44''S	31°32'43'' E
MG35	Ncotshane	27°17'47''S	31°32'51'' E
Bar16	Mbabane	26°17'43''S	31°08'46'' E

Supplementary Table 2: Si isotopic data, SiO_2 contents and key major and trace element ratios for the analysed granitoids.

	Ages (references)	Samples	Group/Lithology	n	(*) [**]	$\delta^{30}Si\pm2\sigma_{\bar{x}}$ ‰	$\delta^{29}Si \pm2\sigma_{\bar{x}}$ ‰	SiO_2 wt%	K_2O/Na_2O	Eu/Eu*	La_N/Yb_N	Lu/Hf	Sr/Y
Steynsdorp	3.51 (a,b)	99/109	TTG/Trondhjemite	3	(6)	+0.04±0.03	+0.01±0.03	65.24	0.32	1.07	5.02	0.047	43.9
		99/122	TTG/Trondhjemite	3	(6)	0.00±0.06	-0.02±0.03	65.25	0.23	1.05	11.2	0.024	59.8
		Bar-6	TTG/Trondhjemite	4	(6)+[6]	-0.04±0.07	-0.02±0.03	71.78	0.46	0.81	12.4	0.070	21.8
Stolzburg	3.46 (c)	99/120	TTG/Trondhjemite	3	(6)	+0.01±0.04	+0.02±0.04	69.78	0.37	0.94	36.8	0.017	106
		Bar-2	TTG/Trondhjemite	4	(6)+[6]	-0.05±0.07	-0.04±0.03	73.64	0.51	1.16	36.9	0.021	228
Theespruit	3.44 (a,d)	99/107	TTG/Trondhjemite	3	(6)	-0.03±0.06	-0.01±0.04	69.01	0.22	1.08	16.5	0.021	100
		99/121	TTG/Trondhjemite	3	(7)	+0.15±0.06	+0.07±0.03	63.90	0.29	0.86	16.9	0.026	70.0
		Bar-3	TTG/Trondhjemite	4	(6)+[6]	-0.02±0.05	0.00±0.03	71.09	0.37	0.88	19.4	0.029	79.7
Badplaas	3.26 (e)	Bar-5	TTG/Trondhjemite	4	(6)+[6]	-0.01±0.05	-0.01±0.03	70.59	0.15	1.29	43.6	0.013	201
Nelshoogte	3.24 (f)	99/106	TTG/Trondhjemite	3	(6)	+0.02±0.07	+0.01±0.04	70.08	0.21	1.21	53.1	0.014	198
		Bar-9	TTG/Trondhjemite	4	(6)+[6]	-0.04±0.04	-0.01±0.03	71.80	0.26	1.29	67.6	0.019	195
Kaap Valley	3.23 (a)	99/128	TTG/Trondhjemite	3	(6)	+0.04±0.06	+0.03±0.04	64.51	0.23	1.08	12.5	0.043	63.6
		Bar-8	TTG/Tonalite	4	(6)+[6]	-0.06±0.03	-0.03±0.04	64.12	0.25	1.11	22.6	0.054	68.6
Dalmein	3.20 (c)	Bar-10	GMS/Granite	4	(6)+[6]	+0.01±0.05	0.00±0.04	70.40	0.55	0.95	31.2	0.050	38.9
		99/108	GMS/Granite	3	(7)	+0.02±0.06	+0.01±0.03	69.80	0.66	0.85	31.4	0.051	34.5
Nelspruit	3.11 (a)	99/118	GMS/Granite	3	(6)	+0.00±0.06	0.00±0.03	71.95	0.52	0.74	60.8	0.015	40.9
		99/110	TTG /Trondhjemite	3	(9)	+0.06±0.06	+0.02±0.04	66.65	0.18	0.81	49.1	0.027	82.7
		99/112	TTG /Trondhjemite	3	(6)	+0.04±0.07	+0.03±0.05	68.48	0.25	0.98	25.3	0.022	70.1
		99/119	GMS/Granite	3	(6)	-0.05±0.04	-0.02±0.03	72.06	0.86	0.58	25.9	0.041	15.4
		Bar-11	GMS/Granite	3	(6)	0.00±0.04	-0.02±0.05	73.97	1.02	0.71	40.4	0.025	29.8
Mpageni	2.74 (a)	Bar-12	GMS/Granite	3	(6)	+0.04±0.06	+0.01±0.03	70.80	0.53	0.58	46.5	0.055	9.4
		99/111	GMS/Granite	3	(8)	-0.14±0.05	-0.06±0.03	74.30	0.73	0.55	54.3	0.050	8.7
Piggs Peak	3.12 (g)	Bar-14	GMS/Granite	3	(7)	+0.04±0.05	+0.02±0.01	70.62	1.76	0.79	22.7	0.056	36.7
		Bar-15	GMS/Granite	3	(5)	+0.02±0.02	0.00±0.01	70.60	1.72	0.83	41.8	0.026	52.8
Salisbury Kop	3.11 (a)	99/115	GMS/Granite	3	(7)	+0.04±0.05	+0.02±0.03	72.77	0.65	0.80	20.9	0.043	28.5
		Bar-13	GMS/Granite	3	(6)	+0.05±0.07	+0.02±0.03	74.34	1.62	0.75	30.7	0.059	13.1
Stentor	3.11 (a)	99/117	GMS/Granite	3	(6)	-0.08±0.04	-0.03±0.03	77.34	0.96	0.27	5.88	0.039	0.84
		Bar-7	GMS/Granite	4	(6)+[6]	-0.08±0.05	-0.03±0.02	74.15	0.84	0.75	39.2	0.036	20.3
Mpuluzi	3.11 (a)	99/126	GMS/Granite	3	(6)	-0.02±0.06	+0.02±0.04	72.29	0.81	0.53	8.12	0.060	8.7
		99/127	GMS/Granite	3	(6)	-0.05±0.06	-0.03±0.01	70.00	0.89	0.41	41.2	0.048	6.8
		Bar-1	GMS/Granite	4	(6)+[6]	-0.05±0.06	-0.03±0.03	69.08	1.11	0.41	42.2	0.051	7.0
Sinceni	3.07 (h)	SINC1	GMS/Granite	3	(6)	-0.04±0.04	0.00±0.02	74.05	1.70	0.17	17.0	0.078	1.7
		SINC2	GMS/Granite	3	(10)	-0.04±0.06	-0.02±0.02	74.88	1.65	0.17	14.8	0.082	1.6
Nhlangano	2.98 (i)	SW5-1	GMS/Granite	3	(6)	-0.09±0.07	-0.05±0.03	73.62	2.49	0.33	10.6	0.058	0.23
Ncotshane gneiss	2.81(j)	MG 18	GMS/Granite	3	(7)	-0.10±0.06	-0.06±0.02	73.13	2.10	0.44	5.37	0.090	0.40
		MG 35	GMS/Granite	3	(6)	-0.04±0.02	-0.01±0.03	78.79	3.19	0.09	11.3	0.074	0.34
Mbabane	2.69 (k)	Bar-16	GMS/Granite	3	(6)	-0.10±0.05	-0.03±0.03	73.70	1.71	0.40	22.9	0.076	3.9
		BHVO-1	Geostan./Basalt	2	[6]	-0.30±0.03	-0.15±0.02	49.94					
		BHVO-2	Geostan./Basalt	6	(25)+[12]	-0.29±0.03	-0.14±0. 02	49.90					

GA	Geostan./I-type granite	7	(70)+[6]	-0.24±0.02	-0.12±0.01	69.9
	Diatomite standard	7	(79)+[9]	+1.26±0.02	+0.65±0.01	

Supplementary Table 2 legend

References : (a) Kamo & Davis (1994) ; (b) Kröner et al., (1996) ; (c) Kröner et al., (2016) ; (d) Kröner et al., (1991); (e) Kisters et al., (2010); (f) Schoene et al. (2008); (g) (Murphy (2015); (h) Maphalala and Kröner (1993); (i) Hofmann et al. (2015); (j) Dlamini et al. (2017); (k) Layer et al. (1989).

n : Number of full chemical replicates starting from a new powder; (∗) Number of solutions analysed with the Nu instrument ; [∗∗] Number of solutions analysed with the Neptune instrument . "Accepted" δ^{30}Si, δ^{29}Si ($\pm 2\sigma_X$) values for standards: BHVO-1 (-0.30±0.05‰, -0.16±0.02‰, Savage et al., 2014); BHVO-2 (-0.30±0.09‰, -0.15±0.04‰, Savage et al., 2014); GA (-0.25±0.03‰, -0.12±0.01‰, Poitrasson & Zambardi, 2015) ; Diatomite (+1.26±0.02‰, +0.64±0.02‰, Reynolds et al., 2007). Eu/Eu*=Eu/(SmxGd)$^{1/2}$.

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Supplementary Table 3 : Average major element (wt%), $\delta^{30}Si$ (‰), K_2O/Na_2O, Lu/Hf, La/Nb and Th/Nb for silicified and unsilicified metabasalts from the Theespruit (Thee.) and Hooggenoeg-Kromberg (Hoog.-Kr.) formations (data from ref. 20, 29) and our proposed source for TTGs (1:3 proportions of Theespruit silicified and unsilicified metabasalts) compared to the average Coucal basalts (C-F2, data from ref. 33, 35) and MORBs (data from ref. 49).

	Hoog.-Kr. Unsilicified Metabasalts (n=4 ± $2\sigma_{\bar{x}}$)	Hoog.-Kr. Silicified Metabasalts (n=10 ± $2\sigma_{\bar{x}}$)	Thee. Unsilicified Metabasalts (n=4 ± $2\sigma_{\bar{x}}$)	Thee. Silicified Metabasalts (n=3 ± $2\sigma_{\bar{x}}$)	TTG Proposed source	C-F2	N-MORB	E-MORB	D-MORB
SiO_2	46.68±6.36	73.46±7.66	48.64±1.20	73.01±14.87	**54.73**	50.00	50.42	50.58	50.39
TiO_2	1.09±0.16	0.94±0.12	1.53±0.42	1.16±0.68	**1.44**	1.53	1.53	1.53	1.51
Al_2O_3	13.85±1.26	11.52±1.30	10.23±3.68	10.52±2.86	**10.30**	13.77	15.13	14.94	14.93
Fe_2O_3	16.38±2.82	2.87±2.38	18.01±1.20	8.03±8.88	**15.51**	13.89	10.90	10.71	11.28
MnO	0.23±0.04	0.05±0.04	0.31±0.08	0.39±0.52	**0.33**	0.24	0.17	0.17	0.18
MgO	7.93±3.12	1.33±0.68	6.72±2.96	2.36±2.46	**5.63**	3.80	7.76	7.37	7.82
CaO	6.41±3.52	1.99±1.60	11.01±3.90	0.84±0.38	**8.47**	7.67	11.35	11.18	11.49
Na_2O	0.71±0.52	0.20±0.16	2.46±0.98	1.42±1.06	**2.20**	2.77	2.83	2.72	2.71
K_2O	1.65±1.30	2.91±0.82	0.14±0.08	0.60±0.64	**0.25**	0.52	0.14	0.39	0.10
P_2O_5	0.07±0.02	0.04±0.02	0.14±0.06	0.09±0.12	**0.08**	0.30	0.16	0.24	0.15
LOI	5.10±2.34	4.66±1.82	2.50±2.54	1.92±1.08	**2.36**	6.49	-	-	-
$\delta^{30}Si$	-0.43±0.16	+0.45±0.18	-0.18±0.16	+0.36±0.14	**0.00**	-	-	-	-
K_2O/Na_2O	2.32	14.6	0.06	0.42	**0.11**	0.19	0.050	0.145	0.035
Lu/Hf	0.229±0.016	0.121±0.038	0.118±0.008	0.109±0.010	**0.117**	0.121	0.195	0.150	0.217
La/Nb	0.916	1.029	0.980	1.358	**1.075**	1.503	1.158	0.704	1.300
Th/Nb	0.086	0.104	0.064	0.054	**0.062**	0.180	0.070	0.065	0.080

Supplementary Table 4. Comparison between Nu and Neptune MC-ICP-MS $\delta^{30}Si$ determinations on Bar 1 to 10 specimens.

(3 measures a,b,c on four different powder aliquots 1 to 4)

Nu		Neptune*		
Aliquot	$\delta^{30}Si$ (‰)	Aliquot	$\delta^{30}Si$ (‰)	ΔNu-Neptune (‰)
Bar1-1a	-0.10	Bar1-3a	-0.16	
Bar1-1b	-0.10	Bar1-3b	-0.19	
Bar1-1c	-0.07	Bar1-3c	-0.10	
Bar1-2a	-0.06	Bar1-4a	0.02	
Bar1-2b	0.01	Bar1-4b	0.10	
Bar1-2c	-0.08	Bar1-4c	0.13	
mean	-0.07		-0.03	-0.04
2sd	*0.08*		*0.28*	
Bar2-1a	-0.16	Bar2-3a	-0.16	
Bar2-1b	-0.07	Bar2-3b	-0.06	
Bar2-1c	0.04	Bar2-3c	-0.15	
Bar2-2a	-0.08	Bar2-4a	0.13	
Bar2-2b	-0.09	Bar2-4b	0.12	
Bar2-2c	-0.11	Bar2-4c	0.04	
mean	-0.08		-0.01	-0.07
2sd	*0.15*		*0.26*	
Bar3-1a	0.05	Bar3-3a	-0.07	
Bar3-1b	-0.04	Bar3-3b	-0.01	
Bar3-1c	0.09	Bar3-3c	0.04	
Bar3-1a	-0.12	Bar3-4a	-0.04	
Bar3-1b	-0.17	Bar3-4b	0.10	
Bar3-1c	-0.05	Bar3-4c	0.04	
mean	-0.04		0.01	-0.05
2sd	*0.20*		*0.13*	
Bar5-1a	0.09	Bar5-3a	-0.14	
Bar5-1b	-0.10	Bar5-3b	0.01	
Bar5-1c	-0.06	Bar5-3c	0.06	
Bar5-2a	-0.05	Bar5-4a	-0.11	
Bar5-2b	0.00	Bar5-4b	-0.04	
Bar5-2c	0.09	Bar5-4c	0.10	
mean	0.00		-0.02	0.02
2sd	*0.16*		*0.19*	
Bar6-1a	-0.05	Bar6-3a	-0.01	
Bar6-1b	-0.03	Bar6-3b	0.14	
Bar6-1c	-0.01	Bar6-3c	-0.13	
Bar6-2a	0.08	Bar6-4a	-0.10	
Bar6-2b	-0.17	Bar6-4b	-0.17	

*Corresponding author

Bar6-2c	-0.16	Bar6-4c	0.17	
mean	-0.06		-0.02	-0.04
2sd	*0.19*		*0.28*	
Bar7-1a	-0.03	Bar7-3a	0.01	
Bar7-1b	-0.20	Bar7-3b	-0.08	
Bar7-1c	-0.14	Bar7-3c	-0.04	
Bar7-1a	-0.07	Bar7-4a	-0.15	
Bar7-1b	0.12	Bar7-4b	-0.14	
Bar7-1c	-0.08	Bar7-4c	-0.13	
mean	-0.07		-0.09	0.02
2sd	*0.22*		*0.13*	
Bar8-1a	-0.15	Bar8-3a	0.01	
Bar8-1b	-0.03	Bar8-3b	-0.10	
Bar8-1c	-0.02	Bar8-3c	-0.05	
Bar8-2a	-0.08	Bar8-4a	-0.05	
Bar8-2b	-0.05	Bar8-4b	0.00	
Bar8-2c	-0.11	Bar8-4c	-0.11	
mean	-0.07		-0.05	-0.02
2sd	*0.17*		*0.10*	
Bar9-1a	-0.11	Bar9-3a	-0.02	
Bar9-1b	-0.10	Bar9-3b	-0.08	
Bar9-1c	0.00	Bar9-3c	0.05	
Bar9-2a	0.05	Bar9-4a	0.04	
Bar9-2b	-0.19	Bar9-4b	0.01	
Bar9-2c	-0.04	Bar9-4c	-0.08	
mean	-0.06		-0.01	-0.05
2sd	*0.17*		*0.12*	
Bar10-1a	-0.01	Bar10-3a	-0.05	
Bar10-1b	0.08	Bar10-3b	-0.03	
Bar10-1c	0.14	Bar10-3c	-0.10	
Bar10-2a	0.08	Bar10-4a	-0.04	
Bar10-2b	-0.05	Bar10-4b	0.01	
Bar10-2c	0.10	Bar10-4c	0.04	
mean	0.05		-0.03	0.08
2sd	*0.14*		*0.10*	

* The measurements on the Neptune (IFREMER, Brest, France) were undertaken on solutions prepared in Belgium in parallel to the Nu measured solutions. They were managed by E. Ponzevera and G. Bayon from Ifremer.

Supplementary Table 5 : Major (in wt%) and trace (in ppm) element concentrations of samples not previously published.

Pluton	Steynsdorp	Stolzburg	Theespruit	Badplaas	Nelshoogte	Kaap Valley
Sample	Bar-6	Bar-2	Bar-3	Bar-5	Bar-9	Bar-8
SiO_2	71.78	73.64	71.09	70.59	71.8	64.12
TiO_2	0.31	0.15	0.23	0.24	0.27	0.51
Al_2O_3	14.79	14.5	15.21	15.84	14.99	15.52
FeOT	2.55	1.25	1.96	2.2	2.16	4.4
MnO	0.04	0.02	0.03	0.03	0.03	0.06
MgO	0.56	0.3	0.87	0.72	0.69	2.7
CaO	2.36	1.66	2.2	3.05	2.85	4.5
Na_2O	4.7	5.13	5.5	5.28	4.98	4.65
K_2O	2.16	2.62	2.01	0.81	1.28	1.16
P_2O_5	0.07	0.03	0.06	0.08	0.08	0.16
LOI	0.51	0.26	0.58	0.98	0.53	2.25
Total	99.83	99.55	99.75	99.8	99.66	100.04
V	16.4	6.6	16.3	13.9	20.4	76.6
Co	109	98.3	114	113	101	70.8
Ga	21.0	16.1	19.4	15.9	17.1	17.7
Rb	53.2	51.7	75.4	28.4	37.2	32.8
Sr	301	502	495	521	498	499
Y	13.8	2.20	6.21	2.59	2.56	7.27
Zr	106	44.8	111	91	106	59.9
Nb	8.98	2.67	6.01	2.48	2.17	3.68
Cs	3.30	1.45	2.46	0.71	1.52	2.23
Ba	391	1165	387	122	164	204
La	23.60	9.29	18.9	14.2	24	22.4
Ce	47.20	18.0	33.8	27.4	45.6	45.4
Pr	4.86	1.94	3.33	2.66	4.3	4.58
Nd	17.8	6.81	11.3	9.14	14.3	16.3
Sm	3.22	1.11	1.99	1.4	1.97	2.7
Eu	0.78	0.35	0.51	0.48	0.62	0.88
Gd	2.72	0.76	1.56	0.92	1.1	2.16
Dy	2.40	0.42	1.11	0.56	0.57	1.46
Ho	0.50	0.08	0.22	0.09	0.1	0.29
Er	1.33	0.19	0.58	0.26	0.27	0.7
Yb	1.29	0.17	0.66	0.22	0.24	0.67
Lu	0.20	0.03	0.1	0.03	0.05	0.09
Hf	2.87	1.45	3.42	2.34	2.64	1.67
Pb	8.99	1.55	8.22	2.12	3.11	2.42
Th	5.87	1.74	6.33	2.03	2.59	2.65
U	1.10	0.49	2.08	0.30	1.68	0.60

Pluton	Dalmein	Nelspruit	Mpageni	Piggs Peak	Piggs Peak	Salisbury Kop
Sample	Bar-10	Bar-11	Bar-12	Bar-14	Bar-15	Bar-13
SiO_2	70.4	73.97	70.8	70.62	70.6	74.34
TiO_2	0.31	0.226	0.299	0.453	0.454	0.103
Al_2O_3	14.85	13.68	15.09	13.67	13.7	13.43
FeOT	2.33	1.608	2.759	3.501	3.456	1.309
MnO	0.05	0.065	0.088	0.066	0.066	<0.05
MgO	0.75	0.337	0.701	0.458	0.449	0.098
CaO	1.9	1.092	2.18	1.587	1.593	0.735
Na_2O	4.99	4.131	4.793	3.139	3.164	3.296
K_2O	2.72	4.224	2.553	5.51	5.457	5.327
P_2O_5	0.15	0.078	0.149	0.139	0.141	<0.05
LOI	1.15	0.44	0.51	0.35	0.32	0.59
Total	99.62	99.85	99.92	99.49	99.4	99.23
V	25	24	12	34	36	20
Co	108	3.3	0.9	4.1	5.5	3.4
Ga	18.1	17.6	14.2	20.6	16.9	15.5
Rb	91.1	115	203	131	157	133
Sr	479	307	251	649	960	273
Y	12.3	10.3	26.8	17.7	18.2	20.8
Zr	128	216	245	117	300	129
Nb	10.8	11.4	26.9	8.9	10.2	10.1
Cs	1.79	1.9	2,0	8.9	4.6	4,0
Ba	574	664	765	512	1602	523
La	51.3	53.2	166	44.4	73.6	71.8
Ce	103	108	307	82.3	155	86.9
Pr	10.20	11.02	28.55	8.65	17.04	12.44
Nd	33.8	38.2	85.9	31.0	63.9	44.5
Sm	5.25	6.50	11.84	5.47	10.37	6.27
Eu	1.37	1.27	1.78	1.27	2.38	1.40
Gd	3.72	4.65	7.55	4.42	7.46	5.17
Dy	2.36	2.43	4.99	3.45	4.00	3.37
Ho	0.48	0.43	0.90	0.66	0.61	0.61
Er	1.15	1.05	2.48	1.70	1.46	1.66
Yb	1.11	0.89	2.41	1.32	1.19	1.58
Lu	0.17	0.14	0.34	0.19	0.18	0.24
Hf	3.4	5.7	6.2	3.4	6.9	4.1
Pb	3.05					
Th	8.88	7.9	40	10.6	8.5	9.3
U	2.42	0.9	7.5	2.7	1.9	2.8

*Corresponding author

Pluton	Stentor	Mpuluzi	Sinceni	Sinceni	Mbabane
Sample	Bar-7	Bar-1	SINC1	SINC2	Bar-16
SiO_2	74.15	69.08	74.05	74.88	73.7
TiO_2	0.15	0.51	0.16	0.10	0.16
Al_2O_3	13.94	14.52	13.76	13.63	13.77
FeOT	1.59	3.31	1.74	1.38	1.76
MnO	0.04	0.07	0	0	<0.05
MgO	0.18	0.6	0.12	0.09	0.13
CaO	0.88	1.49	0.84	0.75	0.84
Na_2O	4.49	4.03	3.25	3.26	3.24
K_2O	3.77	4.46	5.53	5.37	5.54
P_2O_5	0.03	0.16	0.05	0.00	0.05
LOI	0.47	0.93	0.44	0.48	0.71
Total	99.7	99.18	99.93	99.93	99.91
V	6	25	12	9	21
Co	112	87.5	1.10	0.90	4.90
Ga	17.5	23.0	19.4	19.6	17.4
Rb	127	230	422	374	277
Sr	244	236	53.7	55.2	234
Y	12.0	33.8	31.5	34.1	59.70
Zr	150	318	161	162	415
Nb	10.4	46.6	31	32.2	39.0
Cs	3.97	5.35	29.3	14.2	5.70
Ba	913	1190	227	235	875
La	62	168	68.5	68.7	190
Ce	121	337	143	142	344
Pr	12.4	32.5	14.57	14.72	32.85
Nd	42.4	104	49.7	50.1	106
Sm	6.82	15.6	9.23	9.03	15.74
Eu	1.35	1.72	0.45	0.45	1.87
Gd	4.44	10.6	7.35	7.65	12.91
Dy	2.56	7.61	6.33	6.81	10.56
Ho	0.46	1.35	1.20	1.28	2.17
Er	1.1	3.24	3.11	3.35	6.42
Yb	1.07	2.69	2.72	3.14	5.62
Lu	0.17	0.38	0.43	0.45	0.82
Hf	4.7	7.4	5.5	5.5	10.8
Pb	8.06	8.9			
Th	18.1	15.5	36.9	35.5	54.2
U	2.58	3.06	9.8	10.2	7.80